THE
POPULAR SCIENCE
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APRIL, 1907

PIONEERS OF SCIENCE IN AMERICA[1]

BENJAMIN FRANKLIN

BY DR. S. WEIR MITCHELL
PHILADELPHIA, PA.

WE are here, as I understand, to unveil memorial busts of Americans distinguished in science. I, Sir, am honored by the privilege of speaking of Benjamin Franklin. This man, the father of American Science, was possessed of mental gifts unequaled in his day. Even yet he holds the highest place in the intellectual peerage of a land where, in his time, men had few interests which were not material or political. But no man entirely escapes the despotic influences of his period. Thus in every life there are unfulfilled possibilities, and so it was that, paraphrasing Goldsmith, we may say that Franklin to country gave up what was meant for mankind, when with deep regret he resigned, in middle life, all hope of whole-souled devotion to science. When most productive his scientific fertility was the more remarkable because of the other forms of dutiful activity which in a life that knew no rest left small leisure for those hours of quiet thought without which science is unfruitful of result.

[1] There were unveiled at the American Museum of Natural History, New York City, on December 29, ten marble busts of American men of science, designed by Mr. William Couper and presented by Mr. Morris K. Jesup, the president of the museum. The occasion was arranged in honor of the American Association for the Advancement of Science and the affiliated societies meeting at the time in New York City. The exercises took place in the presence of a distinguished audience that crowded the large lecture hall of the museum. By the courtesy of the director of the museum, Dr. Hermon C. Bumpus, we are able to print here the addresses given in connection with the unveiling and photographs of the busts.—EDITOR.

There is a Hall of Fame not built by the hand of man. It is the memory of mankind. In many of its galleries this man's bust could with justice be placed. Diplomacy would claim him as of her greatest. For him would be the laurel of administrative wisdom. Among statesmen he would be welcomed; and who of the masters of English prose shall in that hall of fame be more secure of grateful remembrance, and who more certain of a place among men of science.

As an investigator of nature and of nature's laws he is materially represented here by right of eminent achievement. Let us as men of science feel proud that Franklin's fame as a philosopher did much to win for Franklin the diplomatist such useful consideration and respect as led to final success.

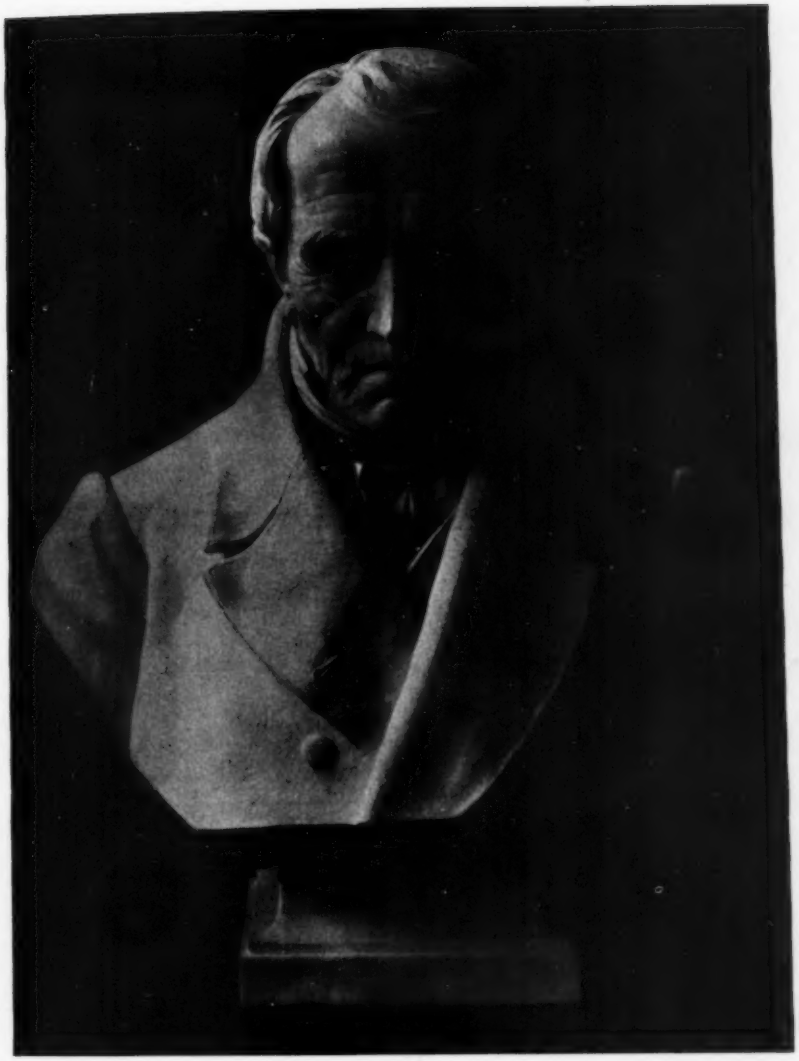
Many of those you honor to-day had moral and temperamental peculiarities which more or less influenced their lives and are common to men of science. Most of them cared little about making money; still less about keeping it. Franklin, on the contrary, dreaded poverty; was careful in business, made fruitful investments and died rich; nevertheless, like the typical man of science, he refused to make money out of his discoveries, or by patents to protect his inventions. In him the man of science, unselfish, free from money greed, seemed to exist apart from all those other men who went to the making of the many-minded Franklin. In another way he was singularly unlike such typical men of science as Henry, in physics, and Leidy, in natural history. When Franklin made a discovery his next thought was as to what practical use it could be put. If he made some novel observation of nature, he asked himself at once how he could make it serve his fellow men. The great reapers of the harvest of truth commonly leave the inventor to make practical use of their unregarded thought.

Leaving the wide land to do justice to Franklin, the model citizen and great diplomatist, here we crown him with the assured verdict of posterity Franklin, the man of pure science. Here we welcome him to this goodly fellowship of those who communed with nature and read the secrets of the Almighty Maker.

Alexander von Humboldt

By Baron Speck von Sternburg
German Embassy, Washington, D. C.

In this immortal man, whose bust you have gathered to unveil, the world reveres its greatest master since the days of Aristotle. His genius covered all that man ever thought, did and observed in nature. There is no branch of human knowledge into which his mind did not



penetrate. His Cosmos, that marvelous monument of meditation and research, is a new book of Genesis in which the universe mirrors itself in all its vastness and minuteness 'from the nebulæ of the stars'—to use his own words—'to the geographical distribution of mosses on granite rocks.'

By his wonderful talent of research, by his almost superhuman power to divine eternal laws, this great interpreter of science taught mankind how to read in the book of nature, how to understand its great mysteries. The series of sciences, originated by this mighty genius is, as well as the other manifold branches of science developed by him, sufficiently known to all of you.

In all his investigations his ultimate aim was to bring theory into practical relation with life. Thus he not only elevated the standard of culture of the whole world by many steps, but he also became from a practical point of view the benefactor of mankind in many branches of common life, as trade, commerce, navigation.

He taught us how to conceive the beauty and sublimity of nature in its every form and motion. His studies are not a matter merely of memory and of dry meditation, to him nature was rather the inexhaustible source of pure and deep enjoyment, by which the heart is purified and ennobled and men are brought nearer to perfection.

It is not necessary to give you a more detailed picture of his life. All this is so well known and so dear to the whole learned world of America; for never has a foreign scholar been more honored in this country than Alexander von Humboldt.

We need only recall the celebrations which took place in his memory, both at the time of his death and on occasion of the centennial anniversary of his birth, when throughout all America solemn offerings of gratitude and devotion went out to the shadow of the great dead.

Humboldt devoted five years of his life to scientific investigations in South and Central America, in Mexico and in Cuba. He ascertained the course of the greatest rivers, he climbed the summits of mountains, where never man's foot had trod before, he studied vegetation, astronomical and meteorological phenomena, gathered specimens of all natural products and a great deal of historical information about the early population of these parts of the New World. It was he that drew the first accurate maps of these regions. With almost prophetic forecast of the needs of generations to come, he examined the Isthmus of Panama and considered carefully the possibilities of establishing an interoceanic waterway.

It is well known how great an interest Alexander von Humboldt has taken in the United States. Indeed, so strongly was he attracted by the problems of the new-born republic that, putting aside even his habitual scientific occupations, he devoted himself entirely for some

months to the study of the American people and the institutions of this country.

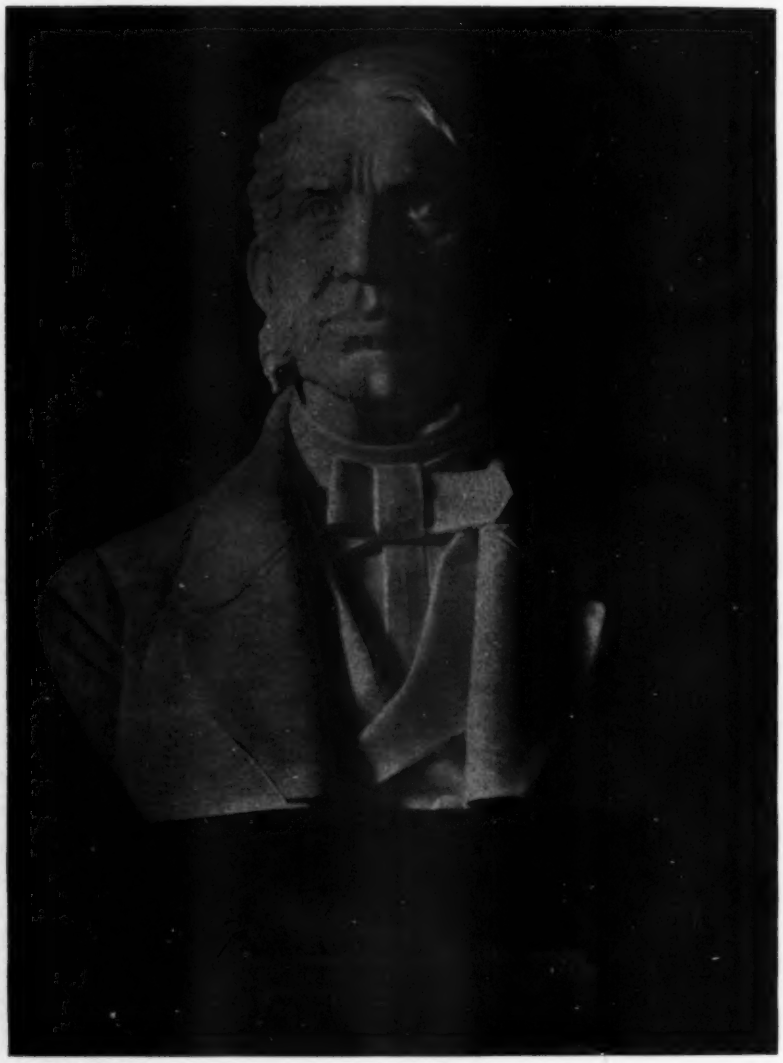
Finally, the great scientist, he whom people call the scientific discoverer of America, returned to his country, carrying with him a vast store of intellectual and material treasures of science. So abundant were the results reaped from his expeditions that he needed the cooperation of the best scholars of his time to compile that great mass of material, and to place it into proper shape and form.

Throughout his long and industrious life, Alexander von Humboldt has ever retained his love and devotion for the country where his great field of labor lay, and for its people to whom he always felt so closely connected by his love for freedom in thoughts and for liberty. It is a well-known fact that in his later days of all foreign people who ever knocked at his door no one was more heartily welcomed than the American citizen.

The benefits of his investigations in America returned to that country in the course of time. No wonder that her people recognize him as their benefactor. Another great man, whose monument will be unveiled to-day, and most deservedly placed beside the one of Alexander von Humboldt, Louis Agassiz, says of him: "To what degree we Americans are indebted to von Humboldt, no one knows who is not familiar with the history of learning and education in this country. All the fundamental facts of popular education in physical science beyond the merest elementary instruction, we owe to him," and at another place: "Let us rejoice together that Humboldt's name will permanently be connected with education and learning in this country, for the prospects and institutions of which he felt so deep and so affectionate a sympathy."

Of all the tributes that have been paid to Alexander von Humboldt the latest and most fitting has now found its expression in this building. For here, in this magnificent Museum of Natural History, the ideal aim of all his theories is realized most perfectly: to cultivate the love of nature, and thus to ennoble man and beautify his life.

Gentlemen, permit me to thank you for the honor you have done me to-day, and to express the hope that this splendid building may become a shrine of pilgrimage for scientists and students also of the Old World, helping to bind the nations closer together.



JOHN TORREY

DR. N. L. BRITTON

DIRECTOR OF THE NEW YORK BOTANICAL GARDEN

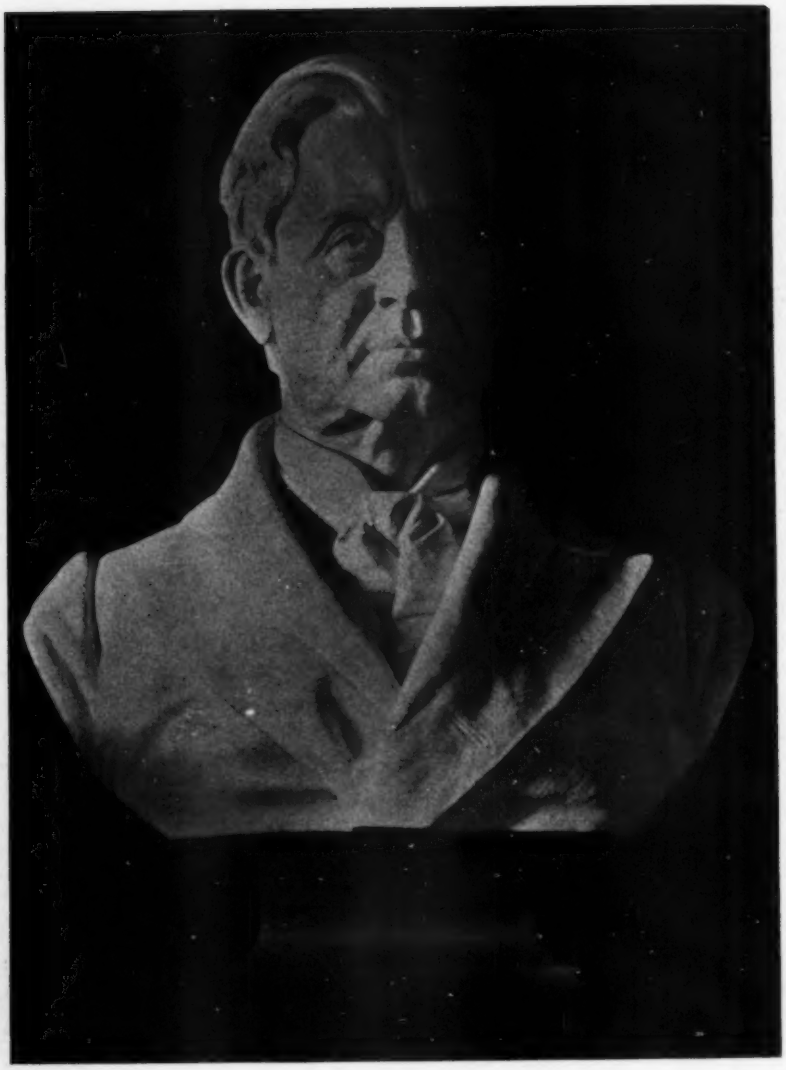
As a pioneer of American botany, John Torrey naturally finds a place among the men whose works we gladly celebrate to-day, in this grand institution, developed in the city where he was born, where he resided the greater part of his life, and where he died. To-day's recognition of Torrey as a master of botanical science is, therefore, peculiarly appropriate in New York, where he is already commemorated by the society which bears his name, by the professorship in Columbia University named in his honor, and by his botanical collections and library deposited by Columbia University at the New York Botanical Garden.

Dr. Torrey was born on August 15, 1796, and died March 10, 1873, nearly thirty-four years ago; the pleasure of his personal acquaintance is, therefore, known to but few persons now living; we have abundant evidence, however, that he was honored and beloved to a degree experienced by but few; righteousness was instinctive in him, aid to others was his pleasure, he was tolerant and progressive, and his genial presence was a delight to his associates.

He was educated for the profession of medicine, graduating from the College of Physicians and Surgeons in 1818, but soon abandoned it and in 1824 became professor of chemistry at West Point; after three years service there, he was elected professor of chemistry and botany in the College of Physicians and Surgeons, a position which he held for nearly thirty years, during part of this period lecturing on chemistry also at Princeton; he was also United States assayer in New York from 1854 until his death.

Dr. Torrey's attention was directed to botany during his youthful association with Professor Amos Eaton, and his interest in that science subsequently stimulated during his medical studies by the lectures of Professor David Hosack. It early became his favorite study, and, notwithstanding his noteworthy services to chemistry, his fame rests on his botanical researches, although they were accomplished durng his hours of rest and recreation, and largely during the night.

His botanical publications began in 1819 with 'A Catalogue of Plants Growing Spontaneously within Thirty Miles of the City of New York,' published by the Lyceum of Natural History, now the New York Academy of Sciences, and were completed the year after his death in the 'Phanerogamia of Pacific North America,' in Vol. 17 of the Report of the United States Exploring Expedition. His contributions to botany include over forty titles, many of them volumes requiring years of patient study; they throw a flood of light on the



plants of North America, and form a grand contribution to knowledge. His collections, on which these researches are based, were annotated and arranged by him with scrupulous care and exactness, and are treasured as among the most important of all scientific material in America.

Joseph Henry

By Dr. ROBERT S. WOODWARD
THE CARNEGIE INSTITUTION

This time, one hundred years ago, Joseph Henry, whose name and fame we honor to-day, was a lad seven years of age. He was born at Albany, New York, of Scotch parentage, his grandparents on both sides having come from Scotland in the same ship to the Colony of New York, in 1775.

Doubtless he had himself in mind when in his mature years he affirmed that "The future character of a child, and that of a man also, is in most cases formed probably before the age of seven years." At any rate, he found himself early, for at the age of sixteen he had determined to devote his life to the acquisition of knowledge. Thus be became, in turn, student, teacher, civil engineer in the service of his native state, professor of mathematics and natural philosophy in the Albany Academy, professor of natural philosophy in the College of New Jersey—now Princeton University—and a pioneer investigator and discoverer of the first order before he was thirty-three years of age.

His inventions and discoveries in electromagnetism especially are of prime importance. They include the inventions of the electromagnetic telegraph and the electromagnetic engine, and the discovery of many of the recondite facts and principles of electromagnetic science.

From the age of thirty-three, when he took up the work of his professorship at Princeton, till the age of forty-seven, when he was called to the post of secretary of the Smithsonian Institution, he pursued his original investigations with untiring zeal and with consummate experimental skill and philosophic insight. It was during this period that Henry and Faraday laid the foundations for the recent wonderful developments of electromagnetic science. The breadth as well as the depth of Henry's learning is indicated by the fact that he found time during this busy period for excursions and for lectures in the fields of architecture, astronomy, chemistry, geology, meteorology and mineralogy, in addition to his lectures and researches in physics.

He was a man rich in experience and ripe in knowledge when, in 1846, he assumed the administative duties implied by the bequest of James Smithson. "To found at Washington, under the name of the

Smithsonian Institution an Establishment for the increase and diffusion of knowledge among men." Henceforth, for thirty-two years, until his death in 1878, he devoted his life to the public service, not alone of our own country, but of the entire civilized world. In this work he manifested the same creative capacity that had distinguished his earlier career in the domain of natural philosophy. He became an organizer and a leader of men. To his wise foresight we owe not only the beneficent achievements of the Smithsonian Institution itself, but also, in large degree, the correspondingly beneficent achievements of the Naval Observatory, the Coast and Geodetic Survey, the Weather Bureau, the Geological Survey, the Bureau of Fisheries and the Bureau of American Ethnology; for to Henry, more than to any other man, must be attributed the rise and the growth in America of the present public appreciation of the scientific work carried on by governmental aid.

We may lament, with John Tyndall, that so brilliant an investigator and discoverer as Henry should have been sacrificed to become so able an administrator. And American devotees to mathematico-physical science may be pardoned for entertaining an elegaic regret that Henry as a pioneer in the fields of electromagnetism did not have the aid of a penetratng mathematical genius, as Faraday had his Maxwell. But posterity, just in its estimtes towards all the world, will recognize in Henry, as we have recognized in our earlier hero, Benjamin Franklin, a many-sided man—a profound student of nature; a teacher whose moral and intellectual presence pointed straight to the goal of truth; an inventor who dedicated his inventions immediately to the public good; a discoverer of the permanent laws which reign in the sphinx-like realm of physical phenomena; an administrator and organizer of large enterprises which have yielded a rich fruitage for the enlightenment and for the melioration of mankind; a leader of men devoted to the progress of science; a patriot, friend and counsellor of Abraham Lincoln in the darker days of the republic —in short, an exemplar for his race, a man whose purity and nobility are here fitly symbolized in enduring marble for our instruction and guidance and for the instruction and the guidance of our successors in the centuries to come.

JOHN JAMES AUDUBON

BY DR. C. HART MERRIAM
U. S. BIOLOGICAL SURVEY

Of the naturalists of America no one stands out in more picturesque relief than Audubon, and no name is dearer than his to the hearts of the American people.

Born at an opportune time, Audubon undertook and accomplished one of the most gigantic tasks that has ever fallen to the lot of one man to perform. Although for years diverted from the path nature intended him to follow, and tortured by half-hearted attempts at a commercial life, against which his restive spirit rebelled, he finally, by the force of his own will, broke loose from his bondage and devoted the remainder of his days to the grand work that has made his memory immortal.

His principal contributions to science are his magnificent series of illustrated volumes on the birds and quadrupeds of North America, his Synopsis of Birds and the Journals of his expeditions to Labrador and to the Missouri and Yellowstone rivers.

The preparation and publication of his elephant folio atlases of life-size colored plates of birds, begun in 1827 and completed in 1838, with the accompanying volumes of text (the 'Ornithological Biography,' 1831–1839), was a colossal task. But no sooner was it accomplished than an equally sumptuous work on the mammals was undertaken, and, with the assistance of Bachman, likewise carried to a successful termination. For more than three quarters of a century the splendid paintings which adorn these works, and which for spirit and vigor are still unsurpassed, have been the admiration of the world.

In addition to his more pretentious works, Audubon wrote a number of minor articles and papers and left a series of Journals, since published by his granddaughter, Miss Maria R. Audubon. The Journals are full to overflowing with observations of value to the naturalist, and, along with the entertaining 'Episodes,' throw a flood of light on contemporary customs and events—and incidentally are by no means to be lost sight of by the historian.

In searching for material for his books, Audubon traveled thousands of miles afoot in various parts of the eastern states, from Maine to Louisiana; he also visited Texas, Florida and Canada, crossed the ocean a number of times, and conducted expeditions to far-away Labrador and the then remote Missouri and Yellowstone Rivers. When we remember the limited facilities for travel in his day—the scarcity of railroads, steamboats and other conveniences—we are better prepared to appreciate the zeal, determination and energy necessary to accomplish his self-imposed task.

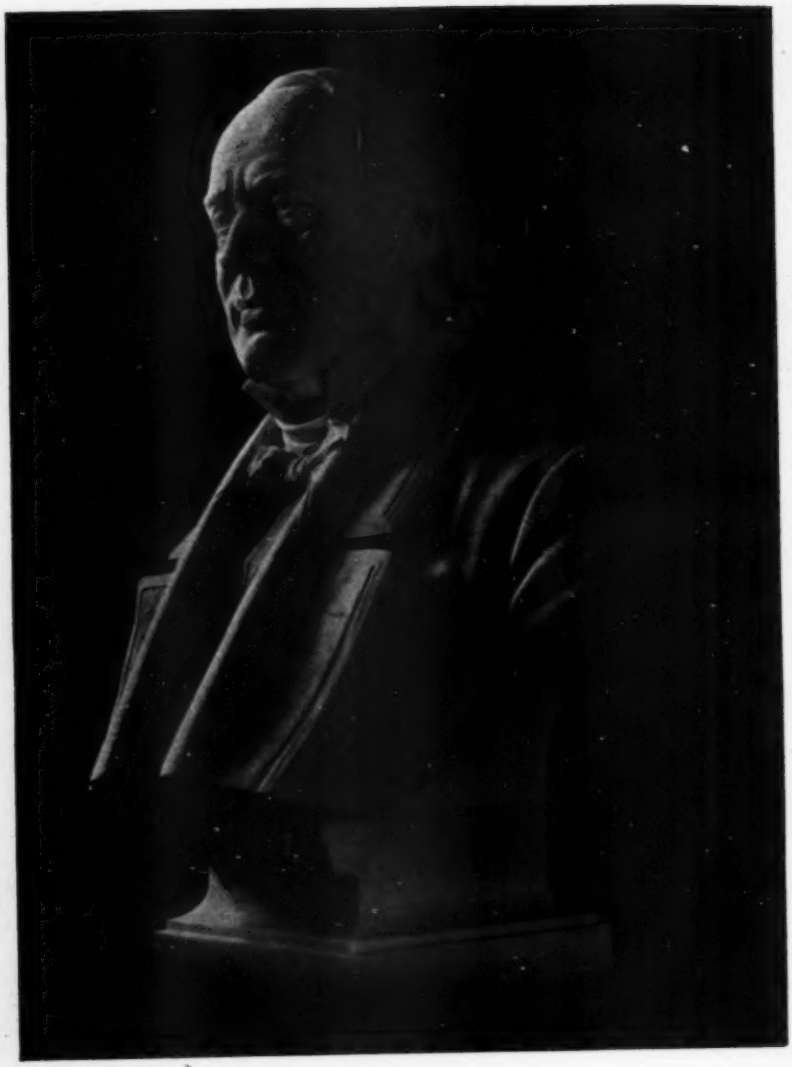
That it was possible for one man to do so much excellent field work, to write so many meritorious volumes, and to paint such a multitude of remarkable pictures must be attributed in no small part to his rare physical strength—for do not intellectual and physical vigor usually go hand in hand and beget power of achievement? Audubon was noted for these qualities. As a worker he was rapid, absorbed and ardent; he began at daylight and labored continuously till night, averaging fourteen hours a day, and, it is said, allowed only four hours for sleep.

In American ornithology, in which he holds so illustrious a place, it was not his privilege to be in the strict sense a pioneer, for before him were Vieillot, Wilson and Bonaparte; and contemporaneous with him were Richardson, Nuttall, Maximilian, Prince of Wied, and a score of lesser and younger lights—some of whom were destined to shine in the near future.

Audubon was no closet naturalist—the technicalities of the profession he left to other—but as a field naturalist he was at his best and had few equals. He was a born woodsman, a lover of wild nature in the fullest sense, a keen observer, an accurate recorder, and, in addition, possessed the rare gift of instilling into his writings the freshness of nature and the vivacity and enthusiasm of his own personality.

His influence was not confined to devotees of the natural sciences, for in his writings and paintings, and in his personal contact with men of affairs, both in this country and abroad, he exhaled the freshness, the vigor, the spirit of freedom and progress of America—and who shall attempt to measure the value of this influence to our young republic?

Audubon's preeminence is due, not alone to his skill as a painter of birds and mammals, nor to the magnitude of his contributions to science, but also to the charm and genius of his personality—a personality that profoundly impressed his contemporaries, and which, by means of his biographies and journals, it is still our privilege to enjoy. His was a type now rarely met—combining the grace and culture of the Frenchman with the candor, patience, and earnestness of purpose of the American. There was about him a certain poetic picturesqueness and a rare charm of manner that drew people to him and enlisted them in his work. His friend, Dr. Bachman, of Charleston, tells us that it was considered a privilege to give to Audubon what no one else could buy. His personal qualities and characteristics appear in some of his minor papers—notably the essays entitled 'Episodes.' These serve to reveal, perhaps better than his more formal writings, the keenness of his insight, the kindness of his heart, the poetry of his nature, the power of his imagination, and the vigor and versatility of his intellect.



Louis Agassiz [1]

By the Rev. EDWARD EVERETT HALE

Boston, Mass.

I think that the first time when I ever saw Agassiz was at one of his own lectures early in his American life. This was a description of his ascent of the Jungfrau. I think it was wholly extempore and though he was new in his knowledge of English, it was idiomatic and thoroughly intelligible. At the end, as he described the last climb, hand and foot, by which as it seems, men come to the little triangular plane, only three feet across, which makes the summit, he quickened our enthusiasm by describing the physical struggle by which he lifted himself so that he could stand on this little three-foot table: He said, 'one by one we stood there, and looked down into Swisserland.' He bowed and retired.

I know I said at once that Mr. Lowell, of our Lowell Institute, who had 'imported Agassiz' (that is James Lowell's phrase), might have said before the audience left the hall, 'You will see, ladies and gentlemen, that we are able to present to you the finest specimen yet discovered of the genus homo of the species intelligens.'

And looking back half a century, on those very first years of his life in America, I think it is fair to say that wherever he went he awakened that sort of personal enthusiasm. And he went everywhere. He was made a professor in Harvard College in 1848. But he never thought of confining himself to any conventional theory of a college professor's work. He was not in the least afraid of making science popular. He flung himself into any or every enterprise by which he could quicken the life of the common schools, and in forty different ways he created a new class of men and women. Naturalists showed themselves on the right hand and on the left. I have seen him address an audience of five hundred people, not twenty of whom when they entered the hall thought they had anything to do with the study of nature. And when after his address they left the hall, all of the five hundred were determined to keep their eyes open and to study nature as she is. From that year 1848, you may trace a steady advance in nature study in the New England schools.

That is to say, that his distinction is that of an educator quite as much as it is that of a naturalist. In 1888, Lowell said, in his quarter-millenial address at Harvard College, that the college trained no great educator, 'for we imported Agassiz.' A great educator he truly was.

When Agassiz was appointed professor he was forty-one years old. In my first personal conversation with him he told me a story, which

[1] A letter read by Professor A. E. Verrill, of Yale University. Interesting remarks were also made by Dr. Charles D. Walcott, Washington, D. C.

may not have got into print, of his own physical strength. He spoke as if it were then an old experience to him. Whether he were twenty-five or thirty-five when it happened, it shows how admirable was his training and his physical constitution. He had been with a party of friends somewhere in eastern Switzerland. They were traveling in their carriages; he was on foot. They parted with the understanding that they were to meet in the Tyrol, at the city of Innsbruck. Accordingly the next morning, Agassiz rose early and started through the mountains by this valley and that, as the compass might direct or his previous knowledge of the region. He did not mean to stop for study and they did not. But he had no special plan as to which hamlet or cottage should cover him at night. Before sundown he came in sight of a larger town than he expected to see, in the distance, and calling a mountaineer, he asked him what that place was. The man said it was Innsbuck. Agassiz said that that could not be so. The man replied with a jeer that he had lived there twenty years, and had always been told that that was the name of the place, but he supposed Agassiz knew better than he did. Accordingly Agassiz determined that he would sleep there and did so. The distance was somewhere near seventy miles. I know it gave me the impression of a walk through the valley passes at the rate of four miles an hour, maintained for sixteen or seventeen hours.

In later life Agassiz made to us some prophecies in which we may trace his enjoyment of the finest physical health and strength. Health and strength indeed belonged to everything which he said and did.

Among other things he said, twenty-five years ago, that the last years of our century—the twentieth—would see a population of a hundred million of people in the valleys of the upper Amazon. I like to keep in memory this brave prophecy because I am sure it will come true.

James Dwight Dana

By President ARTHUR T. HADLEY
YALE UNIVERSITY

It was my privilege to know James Dwight Dana intimately during my early years. To boyhood's imagination his figure typified the man of science; his life personified the spirit of scientific discovery. Wider acquaintance with the world has not in any way dimmed the brightness of that early impression.

The services of the geologist are to-day recognized by every one, and sought by all who can afford them. If he would make a voyage of exploration and discovery, the resources of the world of finance are placed at his disposal. No such aids were given two generations ago.

In Dana's journeyings he had to surmount hardship and peril, and to meet the coldness of those who knew not the value of the quest which he pursued. He and his contemporaries were like the knights errant of chivalry, devoting their lives to an ideal. They were men of faith, who combined the spirit of the missionary and the inspiration of the poet with the clear vision of the observer.

The largeness of Dana's work was commensurate with the largeness of his inspiration. It fell to his lot not only to fill out many pages of the record of the building of the world, as written in the fossil life of America, but to show in important ways the methods by which that building was accomplished. His creative brain never rested content with mere description of facts. He had the more distinctively modern impulse to reconstruct the process by which those facts were brought to pass. From his observations of coral islands in the various stages of their growth he deduced a geologic principle of world-wide importance. It is this characteristic which makes the great modern German school of geologists headed by Suess look to Dana as their precursor, more than to any other man of his generation.

He was not content with the work of discovery alone. The teaching spirit was strong within him. The pioneers in science needed editors and expositors who should make their results known. In each of these capacities Dana's achievements were phenomenal. Of his work as an editor, he has left the files of *The American Journal of Science* as a monument. Of his work as an expositor those who have heard his lectures and attended his class-room exercises can speak with unbounded enthusiasm. He was one of the rare men who by presence and voice and manner could bring the truths and ideals of science home even to those pupils with whom scientific study could never be more than an incident in their lives.

But above all his works and above all his qualities stands the figure of Dana himself—more than an explorer, more than a discoverer, more than a teacher; his countenance, as it were, illuminated by a touch of the light of a new day for which the world was being prepared.

> **His life was gentle; and the elements**
> **So mixed in him that Nature might stand forth**
> **And say to all the world, 'This was a man.'**

Spencer Fullerton Baird

By Dr. HUGH M. SMITH
BUREAU OF FISHERIES

The life, the character, the work of Spencer Fullerton Baird entitle him to recognition in any assemblage and on any occasion where honor is to be paid to those who have been their country's benefactors through illustrious achievements in science.

Developing a taste for scientific pursuits at a very early age, and confirmed in those pursuits through the influence of friendships with Agassiz, Audubon, Dana and other leading scientists of the time, Baird was selected as assistant secretary of the Smithsonian Institution when only twenty-seven years old, and there entered on a career devoted to the promotion, diffusion, and application of scientific knowledge among men, and marked by dignity, sound judgment, fidelity to duty, versatility and general usefulness.

In the many phases of his intellectual development he resembled Franklin and Cope; in the multiplicity of his public duties and in the diversity of the scientific accomplishments in which he attained eminence he had few equals; in founding, organizing and simultaneously directing a number of great national scientific enterprises he was unique among those whose memory is here extolled to-day.

To render an adequate account of the branches of scientific endeavor in which he achieved prominence, benefited his own and future generations and added to his country's renown, one would need to be an ornithologist, a mammalologist, an ichthyologist, a herpetologist, an invertebrate zoologist, an anthropologist, a botanist, a geologist, a paleontologist, a deep-sea explorer, a fishery expert, a fish-culturist, an active administrator of scientific institutions, and an adviser of the federal government in scientific affairs; for Baird was all these and more.

We freely acknowledge to-day the debt that science owed Baird alive and now owes his memory, especially for his inestimable services as assistant secretary and later as secretary of the Smithsonian Institution, as director of the National Museum, and as head of the Commission of Fish and Fisheries. Among all the establishments with which he was connected, this last was preeminently and peculiarly his own. It was conceived by him and created for him, and it would almost appear that he was created for it, for certainly no other person of his day and generation was so admirably fitted for the task of organizing this bureau and of executing the duties that grew out of its functions as successively enlarged by congress. Insisting on scientific investigations and knowledge as the essential basis for all current and prospective utilitarian work, he drew around him a corps of eminent biologists and physicists; he established laboratories; he laid plans for the systematic study of our interior and coastal waters; he had vessels built that were especially designed and equipped for exploration of the seas. While he thus inaugurated operations which have been of lasting benefit to the fisheries, at the same time he became the foremost promoter and exponent of marine research, and the knowledge we to-day possess of oceanic biology and physics is directly or indirectly due to Baird more than to any other person. The rapid development

of piscicultural science under his guidance gave to the United States the foremost place among the nations in maintaining and increasing the aquatic food supply by artificial means; and it was no perfunctory tribute when, in 1880, at the International Fishery Exhibition held in Berlin, Emperor William awarded the grand prize to Baird as 'the first fish-culturist in the world.'

The spirit of Baird influences the Bureau of Fisheries to-day, as it does all other institutions with which he was associated; and since his death, nearly twenty years ago, the good that has been accomplished in the interest of fish-culture and the fishing industry, and in the conduct and encouragement of scientific work, has been in consequence of the foundations he laid, the policy he enunciated and the example he set.

But conspicuous as were his services to science and mankind; faithful and unselfish as was his devotion to the executive responsibilities imposed on him; beautiful as was his personal character, I conceive that his most enduring fame may result from the enthusiasm with which he inspired others and the encouragement and opportunity that he afforded to all earnest workers. The recipients of his aid can be numbered by hundreds, and many of them are to-day his worthy successors in various fields; and their places in turn will gradually be taken by a vast number of men and women who will perpetuate his memory by efficiently and reverently continuing his work.

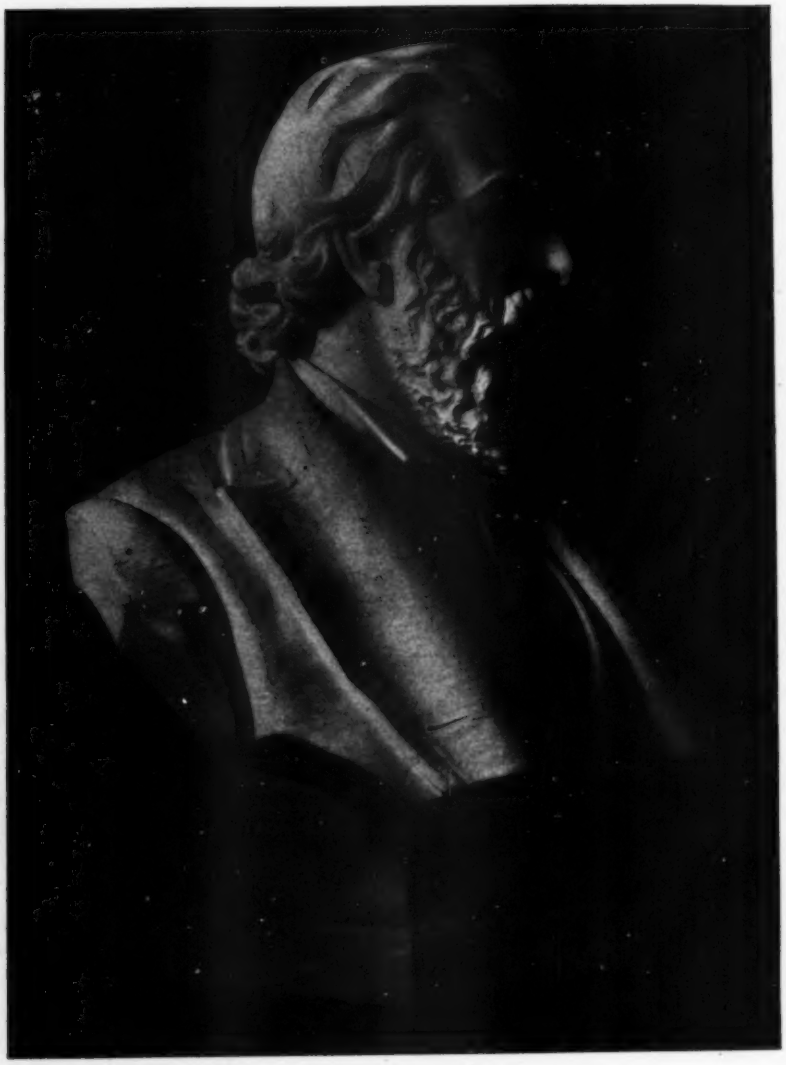
This evidence of the donor's beneficence is a noble and impressive memorial of one who merited his country's profoundest gratitude; but the bust signifies something more, for it is a recognition of that zeal, fidelity, self-sacrifice, intelligence and strength in the American character so preeminently typified by Spencer Fullerton Baird.

JOSEPH LEIDY

BY PROFESSOR WILLIAM KEITH BROOKS
JOHNS HOPKINS UNIVERSITY

Joseph Leidy was born in Philadelphia, there he passed his three score years and ten, and there he died. For forty-five years he was an officer of the Philadelphia Academy of Natural Science, and a professor in the University of Pennsylvania for forty years. His character was simple and earnest, and he had such a modest opinion of his talents and of his work that the honors and rewards that began to come to him in his younger days, from learned societies in all parts of the world, and continued to come for the rest of his life were an unfailing surprise to him.

His knowledge of anatomy, and zoology, and botany, and min-



eralogy was extensive and accurate and at his ready command. Farmers and horticulturists came to him and learned how to check the ravages of destructive insects; physicians sent rare or new human parasites and were told their nature and habits and the best means of prevention; jewelers brought rare gems and learned their value. His comments, at the academy, on the recent additions to its collections, gave a most impressive illustration of his ready command of his vast store of natural knowledge.

Leidy wrote no books, in the popular meaning of the word. He undertook the solution of no fundamental problem of biology. There are few among his six hundred publications that would attract unscientific readers, or afford a paragraph for a newspaper. They are simple and lucid and to the point. Most of them are short, although he wrote several more exhaustive monographs. They cover a wide field, but most of them fall into a few groups. Many deal with the parasites of mammals—among them, one in which his discovery of Trichena in pork is recorded.

Two hundred and sixteen, or about a third of his publications, are on the extinct vertebrates of North America. His first paper on paleontology was published in 1846, and his last in 1888, as the subject occupied him for more than forty years. He laid, with the hand of master, the foundation for the paleontology of the reptiles and mammals of North America, and we know what a wonderful and instructive and world-renowned superstructure his successors have reared upon his foundation. It was this work that established his fame and brought him honors and rewards. They who hold it to be his best title to be enrolled among the pioneers of science in America are in the right in so far as the founder of a great department of knowledge is most deserving of commemoration; but I do not believe it was his most characteristic work.

I can mention but one of the results of his study of American fossils. He showed, in 1846, that this continent is the ancestral home of the horse, and he sketched, soon after, the outline of the story of its evolution which later workers have made so familiar.

More than half his papers are on a subject which seems to me to contain the lesson of his life. Like Gilbert White, he was a home-naturalist, devoted to the study of the natural objects that he found within walking-distance of his home, but he penetrated far deeper into the secrets of the living world about him than White did, finding new wonders in the simplest living being. In the intestine of the cockroach and in that of the white ant, he found wonderful forests of microscopic plants that were new to science, inhabited by minute animals of many new and strange forms. His beautifully illustrated memoir on *A Flora and Fauna within Living Animals* is one of the

most remarkable works in the whole field of biological literature. Another memoir gives the results of his study of the anatomy of snails and slugs. The inhabitants of the streams and ponds in the vicinity of his home furnished an unfailing supply of material for research and discovery, and many of his publications are on aquatic animals. He finally became so much interested in the fresh-water rhizopods that he abandoned all other scientific work in order to devote all his attention to these animals. His results were published in the memoir on *The Fresh-water Rhizopods of North America*. This is the most widely known of his works. It is, and must long be, the standard and classic upon its subject. I have no time to dwell upon his work as the naturalist of the home—his best and most characteristic work. Its lesson to later generations of naturalists seems to me to be that one may be useful to his fellowmen, and enjoy the keen pleasure of discovery, and come to honor and distinction, without visiting strange countries in search of rarities, without biological stations and marine laboratories, without the latest technical methods, without grants of money, and, above all, without undertaking to solve the riddles of the universe or resolving biology into physics and chemistry.

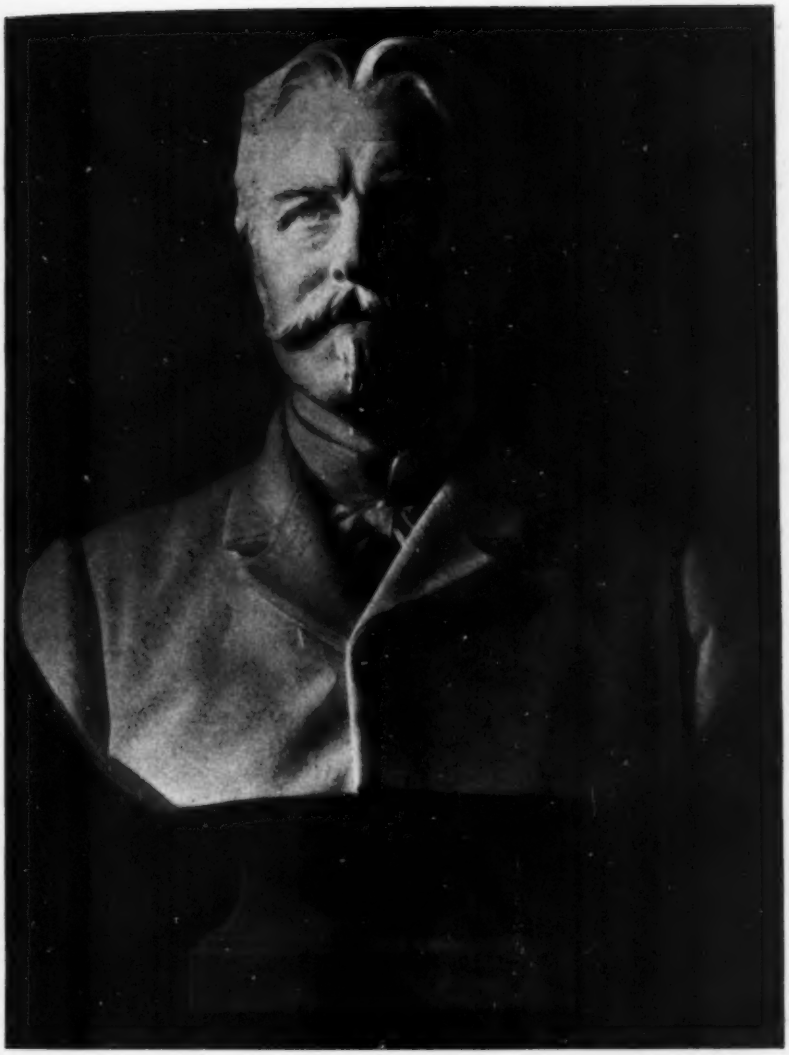
If one have the simple responsive mind of a child or of Leidy, he may, like Leidy, 'find tongues in trees, books in the running brooks, sermons in stones, and good in everything.'

Edward Drinker Cope

By Professor Henry Fairfield Osborn
Columbia University and the American Museum of Natural History

In the beautiful marble portrait of Edward Drinker Cope, modeled by Mr. Couper and presented by President Jesup, you see the man of large brain, of keen eye, and of strong resolve, the ideal combination for a life of science, the man who scorns obstacles, who while battling with the present looks above and beyond. The portrait stands in its niche as a tribute to a great leader and founder of American paleontology, as an inspiration to young Americans. In unison with the other portraits its forcible words are: 'Go thou and do likewise.'

Cope, a Philadelphian, born July 28, 1840, passed away at the early age of fifty-seven. Favored by heredity, through distinguished ancestry of Pennsylvania quakers, who bequeathed intellectual keenness and a constructive spirit. As a boy of eight entering a life of travel and observation, and with rare precocity giving promise of the finest qualities of his manhood. Of incessant activity of mind and



body, tireless as an explorer, early discovering for himself that the greatest pleasure and stimulus of life is to penetrate the unknown in nature. In personal character fearless, independent, venturesome, militant, far less of a quaker in disposition than his Teutonic fellow citizen Leidy. Of enormous productiveness as an editor, conducting the *American Naturalist* for nineteen years, as a writer leaving a shelf-ful of twenty octavo and three great quarto volumes of original research. A man of fortitude, bearing material reverses with good cheer, because he lived in the world of ideas and to the very last moment of his life drew constant refreshment from the mysterious regions of the unexplored.

In every one of the five great lines of research into which he ventured, he reached the mountain peaks where exploration and discovery, guided by imagination and happy inspiration, gave his work a leadership. His studies among fishes alone would give him a chief rank among zoologists, yet among amphibians and reptiles there never has been a naturalist who has published so many papers as Professor Cope, while from 1868 until 1897, the year of his death, he was a tireless student and explorer of the mammals, living and extinct. Among animals of all these classes his generalizations marked new epochs. While far from infallible, his ideas acted as fertilizers on the minds of other men. As a paleontologist, enjoying with Leidy and Marsh that Arcadian period when all the wonders of our great west were new, from his elevation of knowledge which enabled him to survey the whole field, with keen eye he swooped down like an eagle upon the most important point.

In breadth, depth and range we see in Cope the very antithesis of the modern specialist, the last exponent of the race of the Buffon, Cuvier, Owen and Huxley type. Of ability, memory and courage sufficient to grasp the whole field of natural history. As comparative anatomist he ranks with Cuvier and Owen; as paleontologist with Owen, Marsh and Leidy—the other two founders of American paleontology; as natural philosopher less logical but more constructive than Huxley. America will produce men of as great, perhaps greater, genius, but Cope represents a type which is now extinct and never will be seen again.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE

By FRED DE LAND
PITTSBURGH, PA

VIII. Subscribers' Pioneer Telephone Equipment

IN the previous chapter it was shown how the primitive telephone set supplied to subscribers by the New Haven and other pioneer exchanges consisted only of a mahogany or rubber magneto hand telephone hung on a steel hook screwed into wall or board, and how the use of the circuit-breaking push button was the approved method of calling central. No vibrating bell was supplied to the subscriber. When central called, attention was attracted with the aid of a buzzing, squealing noise, that was sent through the telephone by manually and rapidly operating a large induction coil attached to the switchboard. That was the method in vogue early in 1878, and, as already stated, in the beginning it was the custom to use this one-hand telephone as

Fig. 22.

transmitter and receiver, dexterously moving it from lips to ear and from ear to lips, as the conversation progressed. From time to time instructions were issued to subscribers on the proper use of the telephone. One of the first read: 'Do not talk with your ear, or listen with your mouth.' Where a subscriber was willing to pay for 'two telephones,' he enjoyed the unusual convenience of following the now common method of holding the receiver to his ear while talking into the transmitter, as shown in Fig. 22. Not many duplicate telephones

were installed, but occasionally an editor would consider his time of sufficient value to justify the increased outlay of $10 a year for a 'second telephone.'

Following the now famous experiments with his telephones at the Centennial, Alexander Graham Bell had displaced the parchment or membrane diaphragm with one of iron, and brought out the wooden hand telephone to take the place of the oblong box, so inconvenient for general use. Then, in December, 1877, a few long rubber-encased hand telephones similar in form to the present receiver were sent out to several exchanges as an experiment. On July 1, 1878, Mr. Coy had 230 mahogany hand telephones, about 100 rubber hand telephones

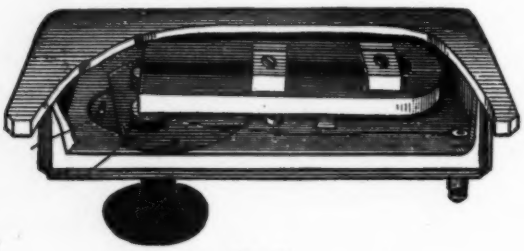


FIG. 23.

and a dozen box telephones. But this rubber hand telephone did not go into general use until the summer of 1878, and, in some exchanges, never really supplanted the original wooden hand telephone, the earlier magneto sets doing so.

Meanwhile an improved form of the oblong box telephone, shown in a previous chapter, was brought out in June, 1877, but met with no favor, as it also required a table or a shelf for its support in a horizontal position. In August, 1877, came the first of the oblong box telephones remodeled so as to be fastened to the wall in a vertical position (Fig. 23). The only telephone circuits in those days were private and social lines, the first commercial exchange opening in January, 1878, and users of projected private lines did not take kindly to this innovation, preferring to have the more convenient hand telephone which could so easily be shifted from lips to ear. And this was the prevailing sentiment even after exchanges were in operation. Thus this upright form of box telephone did not come into general use until the winter of 1878–79, when it served only as part of a subscriber's set.

In the autumn of 1878, the parent Bell company brought out the first of the many forms of magneto bell telephone sets. This early type of wall set (Fig. 24) had the rubber-encased hand telephone hung from a hook projecting through the door on the front of the box. The attaching of two hand telephones to the magneto to serve

as transmitter and receiver (Fig. 25) naturally followed. The introduction of this magneto ringing device displaced the circuit-breaking push-button method of calling central, and the single-stroke bell as part of the subscriber's equipment. It also enabled the local com-

FIG. 24.

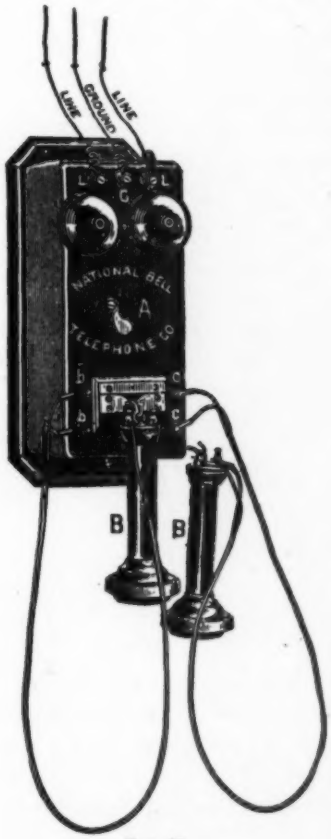


FIG. 25.

panies to secure more equitable rates by increasing the rental where the new equipment was installed.

In the pioneer days when local rates ranged from $18 to $36 per year, nearly all the subscribers were on party-lines, and few lines carried less than twelve telephones. 'How many boxes are there on your line?' was a question often asked by subscribers in the days when it was not unusual to have twelve, or even twenty or more subscribers on a grounded iron-wire circuit in towns. In May, 1878, it was stated that one circuit had 'fifty-six instruments, and conversation is carried on with perfect ease.' Another town boasted of forty-three telephones on one line. Naturally there was more or less eavesdropping, with the usual entailed bitterness. Thus the parent com-

pany found it advisable to sanction the addition of a secrecy-switch to the magneto bells supplied by the different manufacturers. One form of this lock-out switch is shown on the front of the magneto box in Fig. 25. Removing the receiver or hand telephone from the box caused the latter to fly up, just as the hook on the side of the modern telephone does. If the subscriber desired to converse with some one on the line to the right of his telephone, he would turn the switch to the right, thus shutting out all subscribers to the left, but still leaving it possible for eavesdroppers on the right to listen in. If the switch was turned to the left, the subscribers to the right were cut out. To operate the bell it was only necessary to turn the crank at a moderate speed and at the same time to press the button underneath the box the number of times that corresponded with the number of rings required to call the given station.

The next change came in the adoption of the first of the vertical boxes as a transmitter in connection with the magneto-call bell, and the use of the hand telephone as a receiver. In method of operation both instruments were identical, either could be used as transmitter or receiver, and both were fastened to the wall side by side (Fig. 26). The approved method of calling then in vogue is also shown (Fig. 27). The circular of instructions sent out with this early wall set read:

FIG. 26.

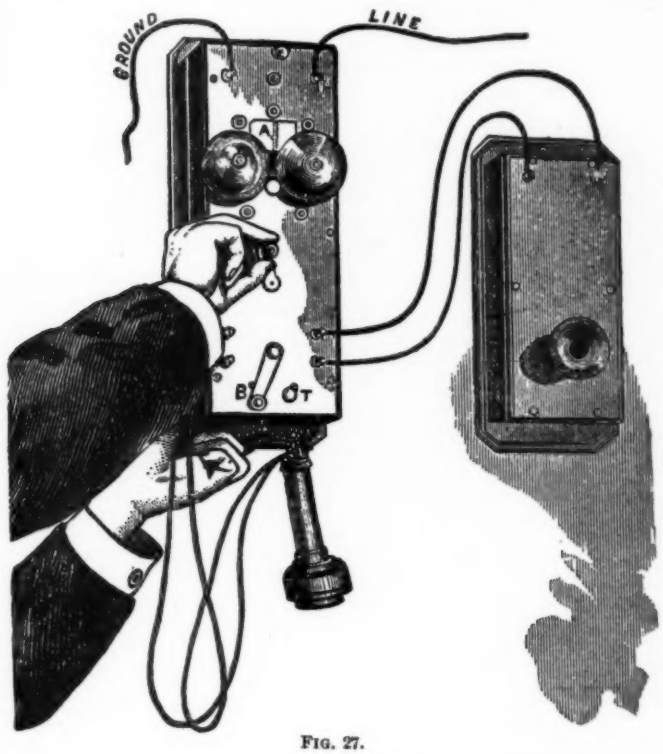


FIG. 27.

A person is shown (Fig. 28) talking to a box telephone, keeping a hand telephone pressed against his ear. It is evident that he can talk or listen without removing either instrument, and consequently can carry on a conversation with as much ease and rapidity as if in the presence of the other person. If he is in a noisy place he can, in listening, turn his other ear to the box telephone, thereby hearing what is said with increased loudness, and at the same time shutting out external sounds. All the telephones described above do not require any battery whatever, and for ordinary purposes are all that can be desired, both for loudness and distinctness.

By reason of its simplicity of operation, the 'push-button magneto' (Fig. 29) type of instrument was popular during its brief existence. In construction and operation it materially differed from the crank instrument. In the latter, the current followed the revolving of an armature within a magnetic field; in the former, the current was produced by pushing the button on the face of the instrument, thus 'forcibly detaching a soft iron armature from the poles of a permanent magnet surrounded with coils of insulated wire.' The following instructions were sent with this instrument in 1880:

To signal the central office, press the black knob *firmly* twice, turn the switch so as to cut out the stations on the same line beyond, then place the telephone to the ear. If there are two black knobs on the instrument, one above

the other, press the upper one steadily while pushing the lower one. If the line is not being used, your bell will ring every time you press the lower knob. If the line is in use, your bell will not ring. As soon as you hear the operator, give him your name and the name of the person to whom you wish to speak; then replace the telephone on the hook. When the person called for is connected with your wire, your bell will ring. Be sure, on removing the telephone again, to turn the hook switch as before, unless notified by the central office to turn in an opposite direction. When you are notified by the central office that a person wishes to speak to you, keep the telephone at your ear, as the person will be ready to speak as soon as you are notified.

Owing to the rapidity with which improvements and modifications in equipment appeared during the first five years, rarely did the subscribers in any two exchanges have the same type of instruments, the newer exchanges having the later types except where the most rigid economy was practised. Yet it often happened that when the patrons in one town learned that the subscribers in an adjoining town had a later type of instruments, the local owners were given no rest until up-to-date instruments were installed, even though the equipment declared to be antiquated and obsolete had been in use only from twelve to eighteen months.

FIG. 28.

Of course, the parent company, through its earnest efforts to afford the operating companies every serviceable improvement, was indirectly responsible for this unavoidable variance in subscriber-equipment. And while modifications in form and improvement in workmanship were not patentable, they were the result of careful and costly experiments in the course of which the parent company was obliged to withdraw from use and condemn many thousands of instruments, not because they were inoperative, but because others were better.' Transmitters and receivers were kept in good condition by the parent company, and replaced with new or improved types as often as necessary without expense to the local company. But the remainder of the equipment had to be purchased from such manufacturers as were able to supply it. Hence, to displace old with new equipment was often a costly change for the local company.

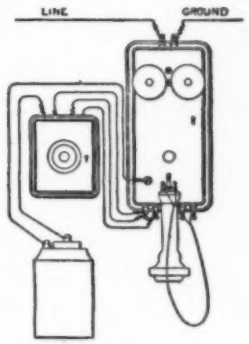


FIG. 29.

In commenting on the trouble caused by defective telephone cords, the Committee on Telephone Supplies reported at the fourth convention (1882) that

> while the telephone business has been one marked with progress, we have to confess that in this respect we have progressed but slowly, if at all. We have had cords of all styles, of all sizes, and constructed of all metallic material from the 'Gold Foil' to the 'Steel Spiral'; from the large and unwieldy to the small and ductile. We have had 'tips' with shields, 'tips' with spirals, and 'tips' without name. We have had forms of eyelets through which the cord is threaded and wrapped with linen. We have had variegated colors from the serpentine braid to the pale blue and the 'polka dot.' We have had all forms but the good. . . . A cord is wanted that will not ravel at the ends, thus causing 'cut-outs' in subscribers' conversations. A greater degree of perfection is required in fastening the tips. They should be light in weight and free from kinks or twists.

In 1883, Mr. C. N. Fay said:

> The first magneto bells we had (in Chicago) came from Boston and were manufactured by Williams, four years ago, and they were certainly the best, so far as lasting qualities were concerned. The next bells we bought, in the fall of 1879, were the first bells Gilliland made. Bells that come in under two years are not worn out, but there is some defect which requires repairing, and then the bell can be put back in service. . . . Their life will not be over four years. If they are not worn out, the dust and the battering they get and the general abuse they receive from subscribers makes them practically worthless after a time, and the subscriber says: 'I won't have that thing on my wall.' We have got to count upon replacing our entire stock of magneto bells about once in every four years.

In one way it was encouraging to the owners of the pioneer local plants to perceive how rapidly the list of subscribers increased. In

another way this unexpectedly rapid growth was depressing in character, because it had not been anticipated and consequently the plant had not been constructed on corresponding lines. Where the investment was not of a speculative nature, but made on a permanent basis, the owners soon realized that they had not been just to themselves nor to the public in building so cheaply and so sparingly. Again, the funds necessary to meet these constantly changing conditions were not readily forthcoming, for not one in ten of the pioneer organizations earned dividends prior to 1882.

In 1880, the parent Bell company gave this sensible advice to its operating companies:

> Don't expect people to 'study up' the instruments themselves, but have them explained politely and patiently. Some large exchanges publish a monthly pamphlet containing corrected lists of subscribers, new information, etc., and defray the whole or part of the expense of its publication by accepting advertisements for alternate pages. A pamphlet issued in this way costs little or nothing, and its monthly coming is appreciated by subscribers. Don't forget that the local papers are a valuable means of popularizing your business. Advertise in them as much as circumstances demand and warrant.

The parent company also stated that printed lists of subscribers should be prepared in 'form like a dancing programme.' Incidentally it may be added that current subscribers' directories in cities like Pittsburgh now weigh about three pounds each, while the directory used in New York City weighs nearly twice as much. The latter contains the names of more than three hundred thousand individuals or firms and about four hundred thousand copies of each issue are distributed. Owing to the frequent revision of Bell subscriber-lists these 'dancing-programmes' are admittedly the most reliable directories in the cities.

Although Graham Bell's hand telephone transmitted messages with remarkable clearness, even over long distances where no disturbing causes interfered, yet it did not possess sufficient power to satisfactorily serve under the varied conditions that developed as the scope of telephone service expanded in all directions. Even though there were no electric-light circuits and no trolley lines, the inductive effect and the zone of noise was always in evidence; for telegraph lines paralleled many telephone circuits and, as practically all lines were grounded, the effect of earth currents was often plainly perceptible. So sensitive was the telephone found to be, that scientists employed it in delicate researches to detect the flow of electrical currents so minute as to be inappreciable to all other instruments. And Graham Bell stated that in standing on a large board placed on his lawn, if a single spear of grass came in contact with his foot while experimenting with his telephone, the effect of ground currents was instantly perceptible, yet disappeared the moment the connection was broken between shoe and grass.

THE GENERAL ECONOMIC IMPORTANCE OF MOSQUITOES[1]

By Professor JOHN B. SMITH
RUTGERS COLLEGE, NEW BRUNSWICK

NO one should be better qualified than a Jerseyman to speak on this subject, for no state in the union has suffered more in reputation and in arrested prosperity from mosquitoes than New Jersey.

During the four or five years last past, I have had opportunity to observe conditions closely, and there is not a section whose development has not been in some way affected by this insect pest.

First: by the carriage of malarial disease, and by the term carriage, I mean, of course, not the direct transmission from one individual to another, but that service as intermediate host in the development of the parasitic organisms that cause the disease.

Anopheles occurs throughout our state, although the *A. maculipennis,* which is the only one of our species known to be affected by the parasite, is comparatively rare and is, curiously enough, more abundant in the more northern, hilly portions than in the southern lowlands, where breeding places are more numerous.

Malarial diseases are much less common with us than they were a few years past, and that is due partially to the improvement of sanitary conditions which lessens mosquito breeding in densely populated districts, and partly to the much more thorough treatment which a patient now receives from the attending physician.

It requires the presence of a patient infested with the plasmodium, as well as of the proper species of *Anopheles,* to start an epidemic of malaria, but the mosquitoes need not be at all common to make trouble. I have in mind an instance very much in point: A village of high-class residences, well-located, generally healthy and where mosquitoes were accounted among the rarities; but, as it happened, the few that did occur were *A. maculipennis.* Into that community, where no case of malaria had ever been known, was introduced a gang of Italian laborers, recent immigrants, it was later found, and most of whom had been affected with the fever in Italy.

Before the end of the season a considerable number of cases of the æstivo-autumnal variety had developed in the village and some of them of the most severe type. This led to a search for the cause, and the breeding places for the few mosquitoes that occurred were located and abolished. Italian laborers have been tabooed in that

locality since then, and for the two years last past no further case has developed, so far as I have been able to find.

The agency of mosquitoes in the transmission of other febrile diseases is so definitely established that their economic importance as a menace to public health can not be doubted. Their agency in a number of other diseases is suspected with good reason. In New Jersey a recent amendment to the general health law classifies 'waters in which mosquito larvæ breed' among the nuisances over which local boards of health have summary jurisdiction, and we have the fullest powers under our law for dealing with the mosquito pest. Action under those powers is not yet the rule, but each year sees a greater advance in this direction.

The great bulk of the mosquitoes occurring in this section of our country are not agents for the transmission of any disease known to us; but their attacks may be, and often are, so annoying as to form a positive injury to the health of weak or sickly individuals by robbing them of sleep and by the constant irritation of their bites. To some persons the bite of a mosquito is really a serious matter and severe swelling and inflammatory conditions are caused. To nobody is it a pleasure to be bitten, and there is no point of view from which the insect is not a detriment to health and the pursuit of happiness.

Second: the influence on the agricultural development of an infested area. This is a point that is rarely referred to, and it is not realized that the character of a farming district may be substantially modified by mosquitoes. Dairying, or supplying milk for the markets of New York, Philadelphia and our own cities, is a very important industry in New Jersey, and a large portion of the Philadelphia supply comes from the southern part of that state. We have a stretch of land in one of these southern counties eminently adapted for dairying, and where herds have been in times past established again and again; but they never lasted long, simply because the incessant attacks by swarms of mosquitoes reduce the yield as well as the quality of milk to such an extent as to make the animals unprofitable. It has been necessary to change the type of agriculture in these areas to a less profitable one simply because of the mosquito pest.

Another section of our state, not far from the shore, is peculiarly adapted to the growing of small fruits, particularly berries of various kinds. These are very profitable and find a ready sale in the near-by resorts. But just about the time when these berries ripen, the country is apt to be flooded with swarms of mosquitoes from the salt marshes, and when they do come it is impossible to get pickers. Gangs of Italians have been brought down from Philadelphia, they have started in

[1] Read at a meeting of the American Society of Tropical Medicine, Philadelphia, December 7, 1906, and published under its imprimatur.

blithely, and by noon have given up the work and started back to the city. Of course such conditions do not occur every year; nor do they continue throughout the season; but they do occur often enough and last long enough to make the farmer hesitate about putting in a crop which he knows would pay if he got it, but which he may be compelled to see rot on the ground because no pickers can be found to brave the mosquito hosts. Few persons are ready to believe at a first statement how important a factor in the agricultural development of a region the mosquito may become.

Third: there is the effect of the mosquito upon the availability of a territory for development as a residential district.

This is the most important feature of the problem in New Jersey today, and there is no exaggeration in the statement that the elimination of the mosquito would add ten millions to the taxable value of real estate in two years. Let me illustrate: New York City is a highly desirable place of residence in winter; but less so in summer, and there are thousands of residents of New York City who are well able to afford a summer home within an hour or two from town, and who are quite willing to pay for it. New Jersey has many places ideal in situation and accessibility, and one such place developed rapidly to a certain point and there it stood, halted by the mosquitoes that bred in the surrounding marsh lands. Country club, golf, tennis and other attractions ceased to attract when attention was necessarily focussed on the biting or singing pests that intruded everywhere, and the tendency was to sell out. But the owners were not ready to quit without a fight, and an improvement society was formed which consulted with my office and followed my advice. In one year the bulk of the breeding area was drained, mosquitoes have since been absent almost entirely; one gentleman, not a large owner, either, told me his property had increased $50,000 in value, and new settlers began to come in. This year one of the worst breeding areas of the olden day was used as a camping ground, and 100 new residences are planned for next year.

New Jersey has miles of sea coast that is unequaled for summer resorts. All but a few points are practically abandoned as uninhabitable. Barnegat Bay and its surroundings constitute a fisherman's paradise, and again and again settlements have started, done well for a season and have been abandoned. Those who came one year never came again, and many who came for a month stayed only a day.

The only thing that prevents a continuous line of summer resorts along the entire shore line is the mosquito pest, and were that removed there would be a scramble to get land.

We may take the result on Staten Island as an example. This Island, now a part of Greater New York, is geographically a portion of New Jersey, separated from the mainland by a narrow stream or

'kill,' on both sides of which salt marsh flats extend for a mile or more to the highland. The southern and eastern shore is a continuation of the New Jersey coast line from the mouth of the Raritan River, and like it has a number of indentations more or less bordered by salt marsh areas. On all these marshes mosquitoes bred in uncounted millions and spread throughout the island. Result: several square miles of most desirable territory for suburban residences entirely unsettled. There are two shore resorts, South Beach and Midland Beach, feeble imitations of Coney Island in some directions, but more desirable in others, that just maintained themselves despite their attractions. During the day conditions were tolerable along shore, but as soon as the sun was low in the horizon trouble began, and as it became dusk the fight began, and pleasure seekers sought shelter behind screens or started for home.

This past summer, under the supervision of Dr. A. H. Doty, state quarantine officer, the salt marshes have been drained in the manner advocated by me, and the beginning was made on the eastern and southern shores, where Midland and South Beach are situated. I need hardly say that very few believed in good results, and scepticism was general even in circles where we might have expected material support But we got the needed money, secured a contractor within our estimate, and the eastern and southern shore work was done before the breeding season set in.

Result: there have been very few mosquitoes of any kind, and practically no marsh mosquitoes along this shore during the entire season. Visitors stayed longer and came more frequently to both beaches, which enjoyed a season of unparalleled prosperity, taxing the full capacity of the transportation companies. As the season advanced, the drainage work extended farther and farther away from the populated sections, permanent residents began to notice that nobody was putting in screens, and that screened porches were never used. On the golf links games could be carried on while the light lasted, and outdoor dinners and suppers became the rule at the Country Club. When it was fully realized that there was practically no mosquito pest, and the improvement in the character of the drained territory was obvious, there was a change in public sentiment. Plans were made for extending the attractions at the beaches, and many thousands will be put into new amusement enterprises during the present winter. Land values stiffened and very little was offered for sale.

Two industrial enterprises decided to locate on the marsh area on the west of the island, and these are expected to employ, respectively, 4,000, and 6,000 men, most of whom will undoubtedly settle near-by. These enterprises will result in actually reclaiming a large section of the marsh, which is something that mosquito drainage does not and was not intended to accomplish.

It is fair, therefore, to consider the mosquitoes of great economic importance, and as serious drawbacks to any community from three points of view:

First, their influence, direct and indirect, upon the health and well-being of the inhabitants.

Second, their influence upon the development of the agricultural resources, preventing or limiting the profitable use of infested territory for certain purposes.

Third, their influence upon land values due to the drawbacks mentioned under 1 and 2.

Having determined these points, it remains to determine whether, in any stage, any species of mosquito is of any value to man, directly or indirectly. The adult is a feeder upon juices of plants and animals; it produces nothing of use to us and removes nothing that is detrimental. It is of absolute importance to the continued existence of those microzoa that pass one stage of their existence in the mosquito body and nowhere else; but no one will argue that it is desirable to continue these organisms, and if the destruction of the mosquito is accompanied by the elimination of Plasmodia, Trypanosomes, Filaria and others of similar ills, a double good will have been accomplished.

In the larval stages the species are feeders upon the microorganisms, animal and vegetable, that occur in more or less stagnant waters. In a way they are scavengers, and it can not be definitely said that they may not destroy or limit some organisms that might otherwise be or become harmful to man. Could it be proved then that these stagnant water areas are necessary, it might be a question whether it is wise to war on mosquitoes until we have a more definite knowledge of the food of the wrigglers. But are these stagnant waters of any use to man, and is it necessary to retain them? On this point also it seems to me the answer must be against the insects, leaving absolutely no evidence that they are of any use or benefit whatever to the human race, directly or indirectly, as larva or adult.

The legislature and governor of New Jersey are sufficiently convinced of the injurious effects of the mosquito upon the development of the state to venture an investment of $350,000 in the effort to secure the practical elimination of the pest.

HOW SHALL THE DESTRUCTIVE TENDENCIES OF MODERN LIFE BE MET AND OVERCOME?

By RICHARD COLE NEWTON, M.D.

WHEN Bichat referred to civilization as 'nothing more than the environment which tends to destroy humankind,' he had in mind, presumably, the so-called civilization of his own time, which we are willing to concede was considerably below that of to-day in every respect and far below that of the Greeks and Romans. To illustrate the superior efficiency of what we may call a natural method of treating diseases over the highly artificial and fanciful methods which prevailed long after Bichat's time, an extract from Higgins's 'Humaniculture' may be paraphrased as follows: It is a matter of record that Augustus Cæsar recovered his health after the expedition into Spain, when suffering from an attack of illness, said to have been due to an inflammation of the liver, by a treatment of baths and an exclusively vegetable diet; whereas, Louis XIV. of France, living 1,600 years later, "in the short space of one year took 215 different medicines, 212 enemata and was bled no less than 47 times." Here is a striking example of progression backwards. As Dr. Higgins sententiously remarks, "A kindly historian would surely take such adverse circumstances into consideration when he gave his judicial opinion on the acts of such unfortunate monarchs."

There are still those who seem to believe that every disease has its appropriate and efficient remedy: a dogma long ago exploded. The only certain remedy for any disease is a man's own vital power. If the body is strong enough and well-nourished enough it will throw off the diseased condition. Drugs, outward applications, mental or spiritual influences, baths, regulation of the diet, ventilation and temperature may be of such efficient and timely aid as to turn the tide of battle from defeat to victory and may help nature to triumph. They, however, are only adjuncts. The natural inherent power of the body itself is the *sine qua non*, the absolute essential; without which all therapeutic measures whatever will prove unavailing.

Admitting then that this condition of bodily vigor is necessary before we can recover from sickness, or can withstand a severe injury, or shock, is it not possible to so train and develop the body that it will be practically non-susceptible to illness and not only that, but so that it will be far more efficient and enduring for all of life's work than the non-trained or improperly developed body? There can be only one answer to this question.

Probably the day has gone by when it is necessary to argue with intelligent people in regard to the relationship between a man's intellectual power and his bodily health and development. Had we not the splendid example of the Greek civilization before us, we could still reason it out from analogy and observation that a healthy mind can not under average conditions exist outside of a healthy body. As President Eliot has neatly put it, "The scholar must use strenuously a tough and alert body and possess a large vitality and a sober courage."

The contempt in which bodily exercise has been held for many centuries and the undue laudation of mental as opposed to physical prowess are to a great extent at least a residuum of the reaction of the ecclesiastical and medical superstitions of the dark ages against the natural methods of the Greek philosophers and against what was considered a too predominant admiration for the physical as opposed to the spiritual side of life. It seems to have been considered heathenish to be well formed and well developed, erect of body and broad of chest. The ideal saint was anæmic to a degree; the ideal successful lawyer or prosperous merchant was of 'full round belly with good capon lined'; the ideal lady was Miss Lydia Languish with wasp-like waist and no organs in particular. For the last half century, however, the reaction toward universal physical prowess and bodily excellence has been advancing, and just now with its gradually accelerated momentum it is making wonderful progress. A great and widespread awakening is taking place in regard to the proposition which I have laid down as axiomatic: that there must be a synchronous and properly balanced development of mind and body, if man is to even approximate his glorious destiny.

Unfortunately, many of the simplest rules relating to the development and care of the human body are as yet enveloped in mystery, or, to speak more exactly, no two authorities seem to agree upon them. The investigation of the régime in vogue in a number of sanatoria by Professor Fisher has demonstrated that scarcely any two of them agree in the diet prescribed for consumptive patients. The calorific value of the prescribed food for each person ranges, in the different institutions, between 2,000 and 5,500 calories per diem, or a difference of 250 per cent. If then in a disease which has received the great amount of attention and study which has been bestowed upon tuberculosis, for a number of years, and in which the modern treatment is mainly confined to the three natural agencies of diet, fresh air and sunlight, there is no accord amongst clinicians as to the standard diet, what wonder is it that in other diseased conditions and more especially in health the greatest confusion prevails in regard to the best form of diet?

Chemical and microscopic experiments in laboratories, however im-

portant, even absolutely essential though they are, will never decide certain vital questions. Note the fantastical deduction of Metchnikoff, who asserts that the large intestine is really a *lusus naturæ*, a dangerous and disease-breeding portion of the economy which had better be dispensed with, at least to the extent of a few feet. The idea does not seem to have dawned upon him that the colon might not be dangerous were it not overloaded with the unused products of an excessive alimentation. Nor can experiments upon animals, nor investigations in the professor's laboratory, ever determine this question, while there are already enough isolated instances on record to render it at least extremely probable that an extended investigation of a sufficient number of human beings would prove that the dangerous element in the life of the modern man is not the anatomical mistake of superabundant intestine, but the overindulgence of a pampered appetite. Nor can *a priori* reasoning be depended upon to settle some very simple controversies, as, for instance, that between the vegetarians and the flesh eaters. So far as the writer knows, no reliable statistics have ever been compiled in regard to the longevity and efficiency of either of these classes as compared with the other. The means for settling this important question lie ready to our hands, viz., a careful collection and analysis of the statistics.

The question of the harmfulness or the innocuousness of tobacco is so far from settlement that certain good authorities declare that its use may be a cause of arterio-sclerosis, while others say that, used in moderation, it is harmless. There is every probability that a properly conducted questionaire would settle this moot point, and so we might undoubtedly settle the question of the real influence of coffee and tea upon the health, and of various articles of diet, as well as meat and fish. Jonathan Hutchinson's contention that fish eating is the cause of leprosy and the commonly accepted belief that beri beri is due to eating musty rice, or even rice in good condition in undue proportion, have an exceedingly important bearing upon the question question of dietetics.

The United States can no longer afford to neglect the experimental study of tropical diseases, since we are building the Panama Canal and have vast tropical possessions in the Philippines, not to mention Porto Rico. There is every encouragement to prosecute such researches when we reflect upon the splendid achievements of our army surgeons, Reed, Gorgas, Ashford, Sternberg and others. Life has been rendered happier and more secure by the devoted scientific labors of these men. Col. Giles has said, speaking of tropical diseases, in regard to the adaptability of the English to life in India, that Clive, being a genius, "naturally possessed the originality to modify his habits to his new surroundings and so survived to become an empire-builder and a

hero. Nor was the case exceptional, for looking back on the history of our great Indian dependency, one can not fail to be struck with the high average ability of the few who survived to attain leading positions. . . . But the rank and file, who could not or would not learn, died off like rotten sheep." So it is to-day in all parts of the globe and nowhere more plainly true than in the United States that only an exceptional man, almost a genius, learns to modify his habits and his life to his environment and to triumph over his surroundings, his appetites and the absurd dictates of fashion. All the world over the genius carves out his proper régime for himself, the average man, ignorantly complaisant, indulges his appetites like the rest of his kind, dies like a rotten sheep and leaves his life-work unfinished.

The foregoing remarks have been confined mainly to diet because that is now the most pressing question before the people of this country and because, as said above, it is a matter upon which the utmost diversity of opinion exists. An observation of 10,000 people for ten years may be necessary to settle the question of the average standard diet for the average man at the different stages of life. If, however, it should take ten times as long and cost an amount equal to the national debt, it would be money and time well expended if the question should be settled thereby. In collating vital statistics, while the time of the death of any one man can not with certainty be predicted, the deaths of ten thousand individuals can be fixed with the nicest accuracy. Nothing can be asserted in regard to the individual, but in regard to the multitude the success of the statistical method is surprising. So in the matter of the health records of one man little can be assumed from a study of his habits; if, however, we could ascertain the life habits of 10,000 men, there is no question but that we could establish certain important truths in regard to them beyond all controversy. And it is equally certain that this is the only method by which some of these truths can be established. There is to-day absolutely nothing known about the etiology of cancer. This dreadful and constantly increasing disease has been studied in every way; in the individual, at the bedside, in the laboratory, in the post-mortem room, by inoculation into animals, etc., etc., and nothing conclusive has been discovered in regard to its causation. Had the life-habits of 10,000 people suffering with cancer been studied as to their diet, their occupation and surroundings, their use of alcohol, tobacco, etc., as well as the questions of heredity, of physical development and of the precedence of other diseased conditions in the same subject, there can be no doubt that important and probably convincing light, would have been shed upon the whole question. Studied in individuals, the cause of this scourge of the race has escaped every effort to locate it; had it been studied collectively, with a large enough number of observa-

tions, its cause would probably have been discovered and its ravages arrested. This probability becomes a certainty if the disease, as has often been asserted, is caused by diet or by residence in certain localities.

Lacking an authoritative standard of such an apparently simple thing as the human diet leaves the people a prey to any glib-tongued person who has any strictly original views to advance or pet theories to advocate. A certain magazine article which recently ridiculed most modern theories of diet and laid special stress on pork and beans as the ideal dietary of the vigorous and progressive, is a fair sample of the mischievous and pseudo-scientific writing which catches the popular eye and may do untold harm. The people deserve and should have a dietary standard, and there should be some competent and properly-equipped body, like the council on pharmacy and chemistry of the American Medical Association, who will spend the necessary time and trouble to settle the questions, not alone of the physiological diet, but of the proper bodily exercise, of ventilation, heating, bathing, etc., etc., in short of personal hygiene; as well as the problems affecting the public health, the pollution of streams and the extinction of tuberculosis.

Furthermore, any new system of therapeutics or any alleged new remedy should be submitted to this body of experts for trial, and approval or condemnation, before it should be possible to advertise it to the public. A variety of methods of treatment are from time to time exploited and no one has the legal right to supervise them or to decide whether, on the one hand, they can do what they are advertised to be able to accomplish or, on the other hand, whether they can be trusted not to harm and injure the people.

If the government can inspect food, it certainly has a right, and should exercise it, to determine, for example, whether or not any newly-advertised method of treatment is safe and appropriate. The objection may be raised against such a proposition as the foregoing that it would be an interference with the personal liberty of which our country is so justly proud; to which the obvious reply is that it is not suggested that any one who wishes to submit to any special course of treatment for a particular disease should be prevented by law from doing so, but every one has a right to know whether the claims of any newly-advertised remedy can be substantiated. In other words, it is no infringement of personal liberty to force a person who professes to have a new and valuable remedy to prove that it is at least not injurious before he shall be allowed to exploit it.

In the material world we have studied everything that grows or exists that can be marketed or used for man's sustenance or comfort, to extend his knowledge, beautify his home, or divert his leisure, but man himself in his most necessary functions, to wit, as an animal,

has not been studied in any comprehensive and thorough manner, unless we may say that the Japanese have done it, since the days of Juvenal who gave us the immortal sentiment '*mens sana in corpore sano.*'

If twentieth-century civilization is to make further advance, if our beloved country is to be much longer inhabited by Americans, if in short the present Anglo-Saxon race is not to die out, steps must be taken to study the conditions of existence and ascertain what measures must be adopted to prevent the terrible waste of human life, now going on without let or hindrance. We are wasteful of many things, but of nothing else are we so wasteful as of human life. And most of this waste is entirely preventable. President Mayo said at the last meeting of the American Medical Association that a sufferer from typhoid fever has as good a right to sue the city where he contracted the filthy complaint as though he had hurt himself by a fall on a defective pavement, and yet we read in the newspapers of epidemics of typhoid fever just broken out in Cincinnati, Newark and other places. Were it outbreak of rinderpest or foot- and mouth-disease, stringent means would be at once taken to stop it and all the forces of the government would be enlisted to save cattle or sheep that have a market value. But human beings may die of typhoid fever, as our soldiers did in Camp Thomas, and no one be called to account; and yet we call ourselves a civilized and a God-fearing nation. Verily our brother's blood shall be required at our hands.

Lyman Abbott said in his baccalaureate sermon at Cambridge that we are entering a period of fraternalism: "There has been autocracy and individualism, but the new life shall be one not of socialism, nor communism, but of fraternalism." We are the keepers of our brother's body, his health, his happiness, his children and his chance to develop and to work out his destiny. We can not escape this responsibility. Knowing its duty, our government must do it and will do it.

Does any one doubt the possible value of government interference in the hygiene of daily life? If so, let him reflect on the diminished death-rate from tuberculosis since the treatment of the disease by fresh air, sunlight and an improved dietary has been so largely inaugurated. The death-rate from this disease in the United States has fallen in twenty years from about 40 per 10,000 of the population annually to about 18 per 10,000, and there is every reason to believe that it can be reduced still lower. The returns furnished in the German tuberculosis congress show a decrease of 38 per cent. in deaths from phthisis in Germany since 1875. The German insurance companies from 1901 to 1905 spent over $9,000,000 in fighting the disease and in establishing thirty-six sanatoria. These sanatoria, together with strict inspection and enforcement of sanitary regulations in that country, are

believed to be the cause of the remarkable decrease in the mortality from consumption.

The diseases of the circulatory and eliminative organs, of which arterio-sclerosis may be cited as the type, are the destructive element which bear off our brain workers and educated men many years before their time. Does any one doubt that these men might live as long, as happily and usefully as Carnaro did, if they will ascertain, as he did, the physiological régime upon which their lives should be governed and act accordingly?

See what Japan, in the science of domestic hygiene certainly the most civilized nation on the globe, has accomplished in the few short years between its war with China and its war with Russia. In the former war three Japanese soldiers died from disease to one who died from wounds. This has been considered the average mortality rate of modern warfare, and so strong is prejudice and so well entrenched is error that this ratio has been looked upon as the inevitable consequence of war, whereas in the Russo-Japanese war, by the exercise of simple and perfectly feasible methods, the ratio of the mortality from sickness to that from wounds in the Japanese army assumed the proportion of one to four and one half, a difference from the accepted ratio of almost 800 per cent. No one would have believed this possible had it not been amply demonstrated. Suppose that an army of United States troops was opposed to a Japanese army. It would not be necessary for the latter to strike a blow or to fire a gun; if they could only hold our army in check for six months disease would do the rest. Do I say disease? I mean the ignorance and officialism which prevents the systematic adoption of the study of the individual soldier and the reasonable precautions which have borne such splendid results in Japan. And shall we decline to undertake similar studies in civil life because this has not been done heretofore? Did not Baron Takaki's epoch-making study of the ration in the Japanese navy stamp out beri beri in that branch of the service and enable Admiral Togo to annihilate the splendid Russian fleet?

We live as though we fully believed that man, of all living animals, is exempt from natural laws or can live superior to them. Race horses, bullocks, poultry, are reared under the strictest rules of diet and hygiene. Our children are left to ignorant nurses, or the divided counsels of improperly instructed medical men. We pass laws to prevent the children of the poor from working nights or in unwholesome surroundings, and yet we allow an overcrowded and ill-advised system of public instruction to seriously and sometimes fatally injure our own children.

There is a glaring hiatus in our educational system. The only remedy is in the proper physical education of children and the in-

struction of parents and teachers in the rules of proper physiological development. Rules for the development and classification of children in the public schools of Chicago have, after much painstaking labor, been pretty well worked out. These results should be collated and compared with similar results obtained in other cities and good working rules deduced from them for national application. Only a board of skilled workers under national control would have the authority, the influence and the means to formulate and apply such rules.

No doubt this proposition will meet with opposition from the stagnant elements of society, known as conservative, and from scientists falsely so-called (being in truth pedants and the greatest hinderance to all true progress). All thinking men will agree, however, that if such an investigation did nothing else, it would tend to develop the physical conscience and clarify the average conception of life. Could people generally be convinced that over-indulgence in flesh food is one of the principal causes, not alone of early decay and death, but of the almost unquenchable human appetite for alcohol and narcotics, an immense stride would have been made in human progress. And it is extremely likely that of the $600,000,000 which this country is said to spend annually in caring for its defectives and criminals, enough could be saved in a few years to carry on such an investigation as we have outlined for a lifetime. 'Science is the only true charity and the only true remedy.' Allowing degeneration, allowing intemperance, allowing immorality, gluttony and ignorance to emasculate our youth, poison the body politic, fill our penal institutions and, worst of all, prevent the proper development of our men and women, is race suicide on a scale not contemplated in ordinary family life, but multiplied by millions, and surely, unless checked, leading to national destruction and disintegration. The remedy is a proper solution of the so-called common questions of life: the neglected body, the despised dietetics, the irksome exercise must be studied by trained and accomplished experts not clinicians, not school teachers, not moralists, not sanitarians in the ordinary acceptation of the term, but specialists in humaniculture, humanists in the true sense, and these great and simple truths, which the Greeks mastered, must be learned over again in the light of modern science (not pedantry), and taught to our children's children; then shall be realized "that future where the highest art and most perfect science will be those of the development of man's faculties and aptitudes to a degree of which the Greek civilization will afford an indication instead of an unattainable ideal."

THE VALUE OF SCIENCE

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Chapter VII. The History of Mathematical Physics

The Past and the Future of Physics

WHAT is the present state of mathematical physics? What are the problems it is led to set itself? What is its future? Is its orientation about to be modified?

Ten years hence will the aim and the methods of this science appear to our immediate successors in the same light as to ourselves; or, on the contrary, are we about to witness a profound transformation? Such are the questions we are forced to raise in entering to-day upon our investigation.

If it is easy to propound them: to answer is difficult. If we felt tempted to risk a prediction, we should easily resist this temptation, by thinking of all the stupidities the most eminent savants of a hundred years ago would have uttered, if some one had asked them what the science of the nineteenth century would be. They would have thought themselves bold in their predictions, and after the event, how very timid we should have found them. Do not, therefore, expect of me any prophecy.

But if, like all prudent physicians, I shun giving a prognosis, yet I can not dispense with a little diagnostic; well, yes, there are indications of a serious crisis, as if we might expect an approaching transformation. Still, be not too anxious: we are sure the patient will not die of it, and we may even hope that this crisis will be salutary, for the history of the past seems to guarantee us this. This crisis, in fact, is not the first, and to understand it, it is important to recall those which have preceded. Pardon then a brief historical sketch.

The Physics of Central Forces

Mathematical physics, as we know, was born of celestial mechanics, which gave birth to it at the end of the eighteenth century, at the moment when it itself attained its complete development. During its first years especially the infant strikingly resembled its mother.

The astronomic universe is formed of masses, very great, no doubt, but separated by intervals so immense that they appear to us only as material points. These points attract each other inversely as the

square of the distance, and this attraction is the sole force which influences their movements. But if our senses were sufficiently keen to show us all the details of the bodies which the physicist studies, the spectacle thus disclosed would scarcely differ from the one the astronomer contemplates. There also we should see material points, separated from one another by intervals, enormous in comparison with their dimensions, and describing orbits according to regular laws. These infinitesimal stars are the atoms. Like the stars proper, they attract or repel each other, and this attraction or this repulsion following the straight line which joins them, depends only on the distance. The law according to which this force varies as function of the distance is perhaps not the law of Newton, but it is an analogous law; in place of the exponent — 2, we have probably a different exponent, and it is from this change of exponent that arises all the diversity of physical phenomena, the variety of qualities and of sensations, all the world, colored and sonorous, which surrounds us; in a word, all nature.

Such is the primitive conception in all its purity. It only remains to seek in the different cases what value should be given to this exponent in order to explain all the facts. It is on this model that Laplace, for example, constructed his beautiful theory of capillarity; he regards it only as a particular case of attraction, or, as he says, of universal gravitation, and no one is astonished to find it in the middle of one of the five volumes of the 'Mécanique céleste.' More recently Briot believes he penetrated the final secret of optics in demonstrating that the atoms of ether attract each other in the inverse ratio of the sixth power of the distance; and Maxwell, Maxwell himself, does he not say somewhere that the atoms of gases repel each other in the inverse ratio of the fifth power of the distance? We have the exponent — 6, or — 5, in place of the exponent — 2, but it is always an exponent.

Among the theories of this epoch, one alone is an exception, that of Fourier; in it are indeed atoms acting at a distance one upon the other; they mutually transmit heat, but they do not attract, they never budge. From this point of view, Fourier's theory must have appeared to the eyes of his contemporaries, to those of Fourier himself, as imperfect and provisional.

This conception was not without grandeur; it was seductive, and many among us have not finally renounced it; they know that one will attain the ultimate elements of things only by patiently disentangling the complicated skein that our senses give us; that it is necessary to advance step by step, neglecting no intermediary; that our fathers were wrong in wishing to skip stations; but they believe that when one shall have arrived at these ultimate elements, there again will be found the majestic simplicity of celestial mechanics.

Neither has this conception been useless; it has rendered us an inestimable service, since it has contributed to make precise the fundamental notion of the physical law.

I will explain myself; how did the ancients understand law? It was for them an internal harmony, static, so to say, and immutable; or else it was like a model that nature tried to imitate. For us a law is something quite different; it is a constant relation between the phenomenon of to-day and that of to-morrow; in a word, it is a differential equation.

Behold the ideal form of physical law; well, it is Newton's law which first clothed it forth. If then one has acclimated this form in physics, it is precisely by copying as far as possible this law of Newton, that is by imitating celestial mechanics. This is, moreover, the idea I have tried to bring out in chapter VI.

The Physics of the Principles

Nevertheless, a day arrived when the conception of central forces no longer appeared sufficient, and this is the first of those crises of which I just now spoke.

What was done then? The attempt to penetrate into the detail of the structure of the universe, to isolate the pieces of this vast mechanism, to analyze one by one the forces which put them in motion, was abandoned, and we were content to take as guides certain general principles the express object of which is to spare us this minute study. How so? Suppose we have before us any machine; the initial wheel work and the final wheel work alone are visible, but the transmission, the intermediary machinery by which the movement is communicated from one to the other, are hidden in the interior and escape our view; we do not know whether the communication is made by gearing or by belts, by connecting-rods or by other contrivances. Do we say that it is impossible for us to understand anything about this machine so long as we are not permitted to take it to pieces? You know well we do not, and that the principle of the conservation of energy suffices to determine for us the most interesting point. We easily ascertain that the final wheel turns ten times less quickly than the initial wheel, since these two wheels are visible; we are able thence to conclude that a couple applied to the one will be balanced by a couple ten times greater applied to the other. For that there is no need to penetrate the mechanism of this equilibrium and to know how the forces compensate each other in the interior of the machine; it suffices to be assured that this compensation can not fail to occur.

Well, in regard to the universe, the principle of the conservation of energy is able to render us the same service. The universe is also a machine, much more complicated than all those of industry, of which

almost all the parts are profoundly hidden from us; but in observing the motion of those that we can see, we are able, by the aid of this principle, to draw conclusions which remain true whatever may be the details of the invisible mechanism which animates them.

The principle of the conservation of energy, or Mayer's principle, is certainly the most important, but it is not the only one; there are others from which we can derive the same advantage. These are:

Carnot's principle, or the principle of the degradation of energy.

Newton's principle, or the principle of the equality of action and reaction.

The principle of relativity, according to which the laws of physical phenomena must be the same for a stationary observer as for an observer carried along in a uniform motion of translation; so that we have not and can not have any means of discerning whether or not we are carried along in such a motion.

The principle of the conservation of mass, or Lavoisier's principle.

I will add the principle of least action.

The application of these five or six general principles to the different physical phenomena is sufficient for our learning of them all that we could reasonably hope to know of them. The most remarkable example of this new mathematical physics is, beyond question, Maxwell's electromagnetic theory of light.

We know nothing as to what the ether is, how its molecules are disposed, whether they attract or repel each other; but we know that this medium transmits at the same time the optical perturbations and the electrical perturbations; we know that this transmission must take place in conformity with the general principles of mechanics, and that suffices us for the establishment of the equations of the electromagnetic field.

These principles are results of experiments boldly generalized; but they seem to derive from their very generality a high degree of certainty. In fact, the more general they are, the more frequent are the opportunities to check them, and the verifications multiplying, taking the most varied, the most unexpected forms, end by no longer leaving place for doubt.

Utility of the Old Physics.—Such is the second phase of the history of mathematical physics and we have not yet emerged from it. Shall we say that the first has been useless? that during fifty years science went the wrong way, and that there is nothing left but to forget so many accumulated efforts that a vicious conception condemned in advance to failure? Not the least in the world. Do you think the second phase could have come into existence without the first? The hypothesis of central forces contained all the principles; it involved them as necessary consequences; it involved both the conservation of

energy and that of masses, and the equality of action and reaction, and the law of least action, which appeared, it is true, not as experimental truths, but as theorems; the enunciation of which had at the same time something more precise and less general than under their present form.

It is the mathematical physics of our fathers which has familiarized us little by little with these various principles; which has habituated us to recognize them under the different vestments in which they disguise themselves. They have been compared with the data of experience, it has been seen how it was necessary to modify their enunciation to adapt them to these data; thereby they have been extended and consolidated. Thus they came to be regarded as experimental truths; the conception of central forces became then a useless support, or rather an embarrassment, since it made the principles partake of its hypothetical character.

The frames then have not broken, because they are elastic; but they have enlarged; our fathers, who established them, did not labor in vain, and we recognize in the science of to-day the general traits of the sketch which they traced.

Chapter VIII. The Present Crisis of Mathematical Physics

The New Crisis.—Are we now about to enter upon a third period? Are we on the eve of a second crisis? These principles on which we have built all, are they about to crumble away in their turn? This has been for some time a pertinent question.

When I speak thus, you no doubt think of radium, that grand revolutionist of the present time, and in fact I shall come back to it presently; but there is something else. It is not alone the conservation of energy which is in question; all the other principles are equally in danger, as we shall see in passing them successively in review.

Carnot's Principle.—Let us commence with the principle of Carnot. This is the only one which does not present itself as an immediate consequence of the hypothesis of central forces; more than that, it seems, if not to directly contradict that hypothesis, at least not to be reconciled with it without a certain effort. If physical phenomena were due exclusively to the movements of atoms whose mutual attraction depended only on the distance, it seems that all these phenomena should be reversible; if all the initial velocities were reversed, these atoms, always subjected to the same forces, ought to go over their trajectories in the contrary sense, just as the earth would describe in the retrograde sense this same elliptic orbit which it describes in the direct sense, if the initial conditions of its motion had been reversed. On this account, if a physical phenomenon is possible,

the inverse phenomenon should be equally so, and one should be able to reascend the course of time. Now, it is not so in nature, and this is precisely what the principle of Carnot teaches us; heat can pass from the warm body to the cold body; it is impossible afterwards to make it take the inverse route and to reestablish differences of temperature which have been effaced. Motion can be wholly dissipated and transformed into heat by friction; the contrary transformation can never be made except partially.

We have striven to reconcile this apparent contradiction. If the world tends toward uniformity, this is not because its ultimate parts, at first unlike, tend to become less and less different; it is because, shifting at random, they end by blending. For an eye which should distinguish all the elements, the variety would remain always as great; each grain of this dust preserves its originality and does not model itself on its neighbors; but as the blend becomes more and more intimate, our gross senses perceive only the uniformity. This is why, for example, temperatures tend to a level, without the possibility of going backwards.

A drop of wine falls into a glass of water; whatever may be the law of the internal motion of the liquid, we shall soon see it colored of a uniform rosy tint, and however much from this moment one may shake it afterwards, the wine and the water do not seem capable of again separating. Here we have the type of the irreversible physical phenomenon: to hide a grain of barley in a heap of wheat, this is easy; afterwards to find it again and get it out, this is practically impossible. All this Maxwell and Boltzmann have explained; but the one who has seen it most clearly, in a book too little read because it is a little difficult to read, is Gibbs, in his 'Elementary Principles of Statistical Mechanics.'

For those who take this point of view, Carnot's principle is only an imperfect principle, a sort of concession to the infirmity of our senses; it is because our eyes are too gross that we do not distinguish the elements of the blend; it is because our hands are too gross that we can not force them to separate; the imaginary demon of Maxwell, who is able to sort the molecules one by one, could well constrain the world to return backward. Can it return of itself? That is not impossible; that is only infinitely improbable. The chances are that we should wait a long time for the concourse of circumstances which would permit a retrogradation; but sooner or later they will occur, after years whose number it would take millions of figures to write. These reservations, however, all remained theoretic; they were not very disquieting, and Carnot's principle retained all its principal value. But here the scene changes. The biologist, armed with his microscope, long ago noticed in his preparations irregular movements of little

particles in suspension; this is the Brownian movement. He first thought this was a vital phenomenon, but soon he saw that the inanimate bodies danced with no less ardor than the others; then he turned the matter over to the physicists. Unhappily, the physicists remained long uninterested in this question; one concentrates the light to illuminate the microscopic preparation, thought they; with light goes heat; thence inequalities of temperature and in the liquid interior currents which produce the movements referred to.

It occurred to M. Gouy to look more closely, and he saw, or thought he saw, that this explanation is untenable, that the movements become brisker as the particles are smaller, but that they are not influenced by the mode of illumination. If then these movements never cease, or rather are reborn without cease, without borrowing anything from an external source of energy, what ought we to believe? To be sure, we should not on this account renounce our belief in the conservation of energy, but we see under our eyes now motion transformed into heat by friction, now inversely heat changed into motion, and that without loss since the movement lasts forever. This is the contrary of Carnot's principle. If this be so, to see the world return backward, we no longer have need of the infinitely keen eye of Maxwell's demon; our microscope suffices. Bodies too large, those, for example, which are a tenth of a millimeter, are hit from all sides by moving atoms, but they do not budge, because these shocks are very numerous and the law of chance makes them compensate each other; but the smaller particles receive too few shocks for this compensation to take place with certainty and are incessantly knocked about. And behold already one of our principles in peril.

The Principle of Relativity.—Let us pass to the principle of relativity: this not only is confirmed by daily experience, not only is it a necessary consequence of the hypothesis of central forces, but it is irresistibly imposed upon our good sense, and yet it also is assailed. Consider two electrified bodies; though they seem to us at rest, they are both carried along by the motion of the earth; an electric charge in motion, Rowland has taught us, is equivalent to a current; these two charged bodies are, therefore, equivalent to two parallel currents of the same sense and these two currents should attract each other. In measuring this attraction, we shall measure the velocity of the earth; not its velocity in relation to the sun or the fixed stars, but its absolute velocity.

I well know what will be said: It is not its absolute velocity that is measured, it is its velocity in relation to the ether. How unsatisfactory that is! Is it not evident that from the principle so understood we could no longer infer anything? It could no longer tell us anything just because it would no longer fear any contradiction. If we succeed

in measuring anything, we shall always be free to say that this is not the absolute velocity, and if it is not the velocity in relation to the ether, it might always be the velocity in relation to some new unknown fluid with which we might fill space.

Indeed, experiment has taken upon itself to ruin this interpretation of the principle of relativity; all attempts to measure the velocity of the earth in relation to the ether have led to negative results. This time experimental physics has been more faithful to the principle than mathematical physics; the theorists, to put in accord their other general views, would not have spared it; but experiment has been stubborn in confirming it. The means have been varied; finally Michelson pushed precision to its last limits; nothing came of it. It is precisely to explain this obstinacy that the mathematicians are forced to-day to employ all their ingenuity.

Their task was not easy, and if Lorentz has got through it, it is only by accumulating hypotheses.

The most ingenious idea was that of local time. Imagine two observers who wish to adjust their timepieces by optical signals; they exchange signals, but as they know that the transmission of light is not instantaneous, they are careful to cross them. When station B perceives the signal from station A, its clock should not mark the same hour as that of station A at the moment of sending the signal, but this hour augmented by a constant representing the duration of the transmission. Suppose, for example, that station A sends its signal when its clock marks the hour O, and that station B perceives it when its clock marks the hour t. The clocks are adjusted if the slowness equal to t represents the duration of the transmission, and to verify it, station B sends in its turn a signal when its clock marks O; then station A should perceive it when its clock marks t. The timepieces are then adjusted.

And in fact they mark the same hour at the same physical instant, but on the one condition, that the two stations are fixed. Otherwise the duration of the transmission will not be the same in the two senses, since the station A, for example, moves forward to meet the optical perturbation emanating from B, whereas the station B flees before the perturbation emanating from A. The watches adjusted in that way will not mark, therefore, the true time; they will mark what may be called the *local time*, so that one of them will gain on the other. It matters little, since we have no means of perceiving it. All the phenomena which happen at A, for example, will be late, but all will be equally so, and the observer will not perceive it, since his watch is slow; so, as the principle of relativity would have it, he will have no means of knowing whether he is at rest or in absolute motion.

Unhappily, that does not suffice, and complementary hypotheses

are necessary; it is necessary to admit that bodies in motion undergo a uniform contraction in the sense of the motion. One of the diameters of the earth, for example, is shrunk by one two-hundred-millionth in consequence of our planet's motion, while the other diameter retains its normal length. Thus the last little differences are compensated. And then, there is still the hypothesis about forces. Forces, whatever be their origin, gravity as well as elasticity, would be reduced in a certain proportion in a world animated by a uniform translation; or, rather, this would happen for the components perpendicular to the translation; the components parallel would not change. Resume, then, our example of two electrified bodies; these bodies repel each other, but at the same time if all is carried along in a uniform translation, they are equivalent to two parallel currents of the same sense which attract each other. This electrodynamic attraction diminishes, therefore, the electrostatic repulsion, and the total repulsion is feebler than if the two bodies were at rest. But since to measure this repulsion we must balance it by another force, and all these other forces are reduced in the same proportion, we perceive nothing. Thus, all seems arranged, but are all the doubts dissipated? What would happen if one could communicate by non-luminous signals whose velocity of propagation differed from that of light? If, after having adjusted the watches by the optical procedure, we wished to verify the adjustment by the aid of these new signals, we should observe discrepancies which would render evident the common translation of the two stations. And are such signals inconceivable, if we admit with Laplace that universal gravitation is transmitted a million times more rapidly than light?

Thus, the principle of relativity has been valiantly defended in these latter times, but the very energy of the defense proves how serious was the attack.

Newton's Principle.—Let us speak now of the principle of Newton, on the equality of action and reaction. This is intimately bound up with the preceding, and it seems indeed that the fall of the one would involve that of the other. Thus we must not be astonished to find here the same difficulties.

Electrical phenomena, according to the theory of Lorentz, are due to the displacements of little charged particles, called electrons, immersed in the medium we call ether. The movements of these electrons produce perturbations in the neighboring ether; these perturbations propagate themselves in every direction with the velocity of light, and in turn other electrons, originally at rest, are made to vibrate when the perturbation reaches the parts of the ether which touch them. The electrons, therefore, act on one another, but this action is not direct, it is accomplished through the ether as intermediary. Under

these conditions can there be compensation between action and reaction, at least for an observer who should take account only of the movements of matter, that is, of the electrons, and who should be ignorant of those of the ether that he could not see? Evidently not. Even if the compensation should be exact, it could not be simultaneous. The perturbation is propagated with a finite velocity; it, therefore, reaches the second electron only when the first has long ago entered upon its rest. This second electron, therefore, will undergo, after a delay, the action of the first, but will certainly not at that moment react upon it, since around this first electron nothing any longer budges.

The analysis of the facts permits us to be still more precise. Imagine, for example, a Hertzian oscillator, like those used in wireless telegraphy; it sends out energy in every direction; but we can provide it with a parabolic mirror, as Hertz did with his smallest oscillators, so as to send all the energy produced in a single direction. What happens then according to the theory? The apparatus recoils, as if it were a cannon and the projected energy a ball; and that is contrary to the principle of Newton, since our projectile here has no mass, it is not matter, it is energy. The case is still the same, moreover, with a beacon light provided with a reflector, since light is nothing but a perturbation of the electromagnetic field. This beacon light should recoil as if the light it sends out were a projectile. What is the force that should produce this recoil? It is what is called Maxwell-Bartholdi pressure. It is very minute, and it has been difficult to put it in evidence even with the most sensitive radiometers; but it suffices that it exists.

If all the energy issuing from our oscillator falls on a receiver, this will act as if it had received a mechanical shock, which will represent in a sense the compensation of the oscillator's recoil; the reaction will be equal to the action, but it will not be simultaneous; the receiver will move on, but not at the moment when the oscillator recoils. If the energy propagates itself indefinitely without encountering a receiver, the compensation will never occur.

Shall we say that the space which separates the oscillator from the receiver and which the perturbation must pass over in going from the one to the other is not void, that it is full not only of ether, but of air, or even in the interplanetary spaces of some fluid subtile but still ponderable; that this matter undergoes the shock like the receiver at the moment when the energy reaches it, and recoils in its turn when the perturbation quits it? That would save Newton's principle, but that is not true. If energy in its diffusion remained always attached to some material substratum, then matter in motion would carry along light with it, and Fizeau has demonstrated that it does nothing of the sort, at least for air. Michelson and Morley have since confirmed this.

It might be supposed also that the movements of matter proper are exactly compensated by those of the ether; but that would lead us to the same reflections as before now. The principle so understood will explain everything, since, whatever might be the visible movements, we always could imagine hypothetical movements which compensate them. But if it is able to explain everything, this is because it does not enable us to foresee anything; it does not enable us to decide between the different possible hypotheses, since it explains everything beforehand. It therefore becomes useless.

And then the suppositions that it would be necessary to make on the movements of the ether are not very satisfactory. If the electric charges double, it would be natural to imagine that the velocities of the diverse atoms of ether double also, and for the compensation, it would be necessary that the mean velocity of the ether quadruple.

This is why I have long thought that these consequences of theory, contrary to Newton's principle, would end some day by being abandoned, and yet the recent experiments on the movements of the electrons issuing from radium seem rather to confirm them.

Lavoisier's Principle.—I arrive at the principle of Lavoisier on the conservation of mass. Certainly, this is one not to be touched without unsettling all mechanics. And now certain persons think that it seems true to us only because in mechanics merely moderate velocities are considered, but that it would cease to be true for bodies animated by velocities comparable to that of light. Now these velocities, it is believed at present, have been realized; the cathode rays or those of radium may be formed of very minute particles or of electrons which are displaced with velocities smaller no doubt than that of light, but which might be its one tenth or one third.

These rays can be deflected, whether by an electric field, or by a magnetic field, and we are able, by comparing these deflections, to measure at the same time the velocity of the electrons and their mass (or rather the relation of their mass to their charge). But when it was seen that these velocities approached that of light, it was decided that a correction was necessary. These molecules, being electrified, can not be displaced without agitating the ether; to put them in motion it is necessary to overcome a double inertia, that of the molecule itself and that of the ether. The total or apparent mass that one measures is composed, therefore, of two parts: the real or mechanical mass of the molecule and the electrodynamic mass representing the inertia of the ether.

The calculations of Abraham and the experiments of Kaufmann have then shown that the mechanical mass, properly so called, is null, and that the mass of the electrons, or, at least, of the negative electrons, is of exclusively electrodynamic origin. This is what forces us

to change the definition of mass; we can not any longer distinguish mechanical mass and electrodynamic mass, since then the first would vanish; there is no mass other than electrodynamic inertia. But in this case the mass can no longer be constant; it augments with the velocity, and it even depends on the direction, and a body animated by a notable velocity will not oppose the same inertia to the forces which tend to deflect it from its route, as to those which tend to accelerate or to retard its progress.

There is still a resource; the ultimate elements of bodies are electrons, some charged negatively, the others charged positively. The negative electrons have no mass, this is understood; but the positive electrons, from the little we know of them, seem much greater. Perhaps they have, besides their electrodynamic mass, a true mechanical mass. The real mass of a body would, then, be the sum of the mechanical masses of its positive electrons, the negative electrons not counting; mass so defined might still be constant.

Alas! this resource also evades us. Recall what we have said of the principle of relativity and of the efforts made to save it. And it is not merely a principle which it is a question of saving, it is the indubitable results of the experiments of Michelson.

Well, as was above seen, Lorentz, to account for these results, was obliged to suppose that all forces, whatever their origin, were reduced in the same proportion in a medium animated by a uniform translation; this is not sufficient; it is not enough that this take place for the real forces, it must also be the same for the forces of inertia; it is therefore necessary, he says, that *the masses of all the particles be influenced by a translation to the same degree as the electromagnetic masses of the electrons.*

So the mechanical masses must vary in accordance with the same laws as the electrodynamic masses; they can not, therefore, be constant.

Need I point out that the fall of Lavoisier's principle involves that of Newton's? This latter signifies that the center of gravity of an isolated system moves in a straight line; but if there is no longer a constant mass, there is no longer a center of gravity, we no longer know even what this is. This is why I said above that the experiments on the cathode rays appeared to justify the doubts of Lorentz concerning Newton's principle.

From all these results, if they were confirmed, would arise an entirely new mechanics, which would be, above all, characterized by this fact, that no velocity could surpass that of light,[1] any more than any temperature can fall below absolute zero.

[1] Because bodies would oppose an increasing inertia to the causes which would tend to accelerate their motion; and this inertia would become infinite when one approached the velocity of light.

No more for an observer, carried along himself in a translation he does not suspect, could any apparent velocity surpass that of light; and this would be then a contradiction, if we did not recall that this observer would not use the same clocks as a fixed observer, but, indeed, clocks marking 'local time.'

Here we are then facing a question I content myself with stating. If there is no longer any mass, what becomes of Newton's law? Mass has two aspects: it is at the same time a coefficient of inertia and an attracting mass entering as factor into Newtonian attraction. If the coefficient of inertia is not constant, can the attracting mass be? That is the question.

Mayer's Principle.—At least, the principle of the conservation of energy yet remained to us, and this seemed more solid. Shall I recall to you how it was in its turn thrown into discredit? This event has made more noise than the preceding, and it is in all the memoirs. From the first works of Becquerel, and, above all, when the Curies had discovered radium, it was seen that every radioactive body was an inexhaustible source of radiation. Its activity seemed to subsist without alteration throughout the months and the years. This was in itself a strain on the principles; these radiations were in fact energy, and from the same morsel of radium this issued and forever issued. But these quantities of energy were too slight to be measured; at least that was the belief and we were not much disquieted.

The scene changed when Curie bethought himself to put radium in a calorimeter; it was then seen that the quantity of heat incessantly created was very notable.

The explanations proposed were numerous; but in such case we can not say, 'store is no sore.' In so far as no one of them has prevailed over the others, we can not be sure there is a good one among them. Since some time, however, one of these explanations seems to be getting the upper hand and we may reasonably hope that we hold the key to the mystery.

Sir W. Ramsay has striven to show that radium is in process of transformation, that it contains a store of energy enormous but not inexhaustible. The transformation of radium then would produce a million times more heat than all known transformations; radium would wear itself out in 1,250 years; this is quite short, and you see that we are at least certain to have this point settled some hundreds of years from now. While waiting, our doubts remain.

A DEFENCE OF PRAGMATISM[1]

II. What Pragmatism Means

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SOME years ago, being with a camping party in the mountains, I returned from a solitary ramble to find every one engaged in a ferocious metaphysical dispute. The *corpus* of the dispute was a squirrel—a live squirrel supposed to be clinging to one side of a tree-trunk; while over against the tree's opposite side a human being was imagined to stand. This human witness tries to get sight of the squirrel by moving rapidly round the tree, but no matter how fast he goes, the squirrel moves as fast in the opposite direction, and always keeps the tree between himself and the man, so that never a glimpse of him is caught. The resultant metaphysical problem now is this: *Does the man go round the squirrel or not?* He goes round the tree, sure enough, and the squirrel is on the tree; but does he go round the squirrel? In the unlimited leisure of the wilderness, discussion had been worn threadbare. Every one had taken sides, and was obstinate, and the numbers on both sides were even. Each side, when I appeared, therefore, appealed to me to make it a majority. Mindful of the scholastic adage that whenever you meet a contradiction you must make a distinction, I immediately sought and found one, as follows: "Which party is right," I said, "depends on what you *practically mean* by 'going round' the squirrel. If you mean passing from the north of him to the east, then to the south, then to the west, and then to the north of him again, obviously the man does go round him, for he occupies these successive positions. But if, on the contrary, you mean being first in front of him, then on the right of him, then behind him, then on his left, and finally in front again, it is quite as obvious that the man fails to go round him, for by the compensating movements the squirrel makes, he keeps his belly turned towards the man all the time, and his back turned away. Make the distinction, and there is no occasion for any further dispute. You are both right and both wrong according as you conceive the verb 'to go round' in one way or another practical fashion."

Although one or two of the hotter disputants called my speech a

[1] The second of a course of eight lectures on 'Pragmatism: A New Name for an Old Way of Thinking,' given before the Lowell Institute, Boston, and the Departments of Philosophy and Psychology, Columbia University.

shuffling evasion, saying they wanted no quibbling or scholastic hair-splitting, but meant just plain honest English 'round,' the majority seemed to think that the distinction had assuaged the dispute.

I tell this trivial anecdote because it is a peculiarly simple example of what I wish now to speak of as *the pragmatic method.*' The pragmatic method is primarily a method of settling metaphysical disputes that otherwise might be interminable. Is the world one or many?—fated or free?—material or spiritual?—here are notions either of which may or may not hold good of the world; and disputes over such notions are unending. The pragmatic method in such cases is to try to interpret each notion by tracing its respective practical consequences. What difference would it practically make to any one if this notion rather than that one were true? If no practical difference whatever can be traced, then the alternatives mean practically the same thing, and all dispute is idle. Whenever a dispute is serious, we ought to be able to show some practical difference that must follow from one side or the other's being right.

A glance at the history of the idea will show you still better what pragmatism means. The word is derived from the same Greek term πραγμα, meaning action, from which our words 'practise' and 'practical' come. It was first introduced into philosophy by Mr. Charles Peirce in 1878. In an article in the POPULAR SCIENCE MONTHLY for that year[2] Mr. Peirce, after pointing out that our beliefs are really rules for action, said that, to develop a thought's meaning, we need only determine what conduct it is fitted to produce; that conduct is for us its sole significance. And the tangible fact at the root of all our thought-distinctions, however subtle, is that there is no one of them so fine as to consist in anything but a possible difference of practise. To attain perfect clearness in our thoughts of an object, then, we need only consider what effects of a conceivably practical kind the object may involve—what sensations we are to expect from it, and what reactions we must prepare. Our conception of these effects, whether immediate or remote, is then for us the whole of our conception of the object, so far as that conception has positive significance at all.

This is the principle of Peirce, the principle of pragmatism. It lay entirely unnoticed by any one for twenty years, until I, in an address before Professor Howison's Philosophical Union at the University of California, brought it forward again, quoting Peirce, and making a certain application of it to religion. By that date (1898) the times seemed ripe for its reception. The word 'pragmatism' spread, and at present it fairly spots the pages of the philosophic journals. On all hands we find the 'pragmatic movement' spoken of, sometimes with respect, sometimes with contumely, seldom with clear understanding.

[2] January, 1878, 'How to Make Our Ideas Clear.'

It is evident that the term applies itself conveniently to a number of tendencies that hitherto have lacked a collective name, and that it has 'come to stay.'

To take in the importance of Peirce's principle, one must get accustomed to applying it to concrete cases. I found a few years ago that Ostwald, the illustrious Leipzig chemist, had been making perfectly distinct use of the principle of pragmatism in his lectures on the philosophy of science, though he had not called it by that name.

"All realities influence our practise," he wrote me, "and that influence is their meaning for us. I am accustomed to put questions to my classes in this way: In what respects would the world be different if this alternative or that were true? If I can find nothing that would become different, then the alternative has no sense."

That is, the rival views mean practically the same thing, and meaning, other than practical, there is for us none. Ostwald in a published lecture gives this example of what he means. Chemists have long wrangled over the inner constitution of certain bodies called 'tautomerous.' Their properties seemed equally consistent with the notion that an instable hydrogen atom oscillates inside of them, or that they are instable mixtures of two bodies. Controversy raged; but never was decided. "It would never have begun," says Ostwald, "if the combatants had asked themselves what particular experimental fact could have been made different by one or the other view being correct. For it would then have appeared that no difference of fact could possibly ensue; and the quarrel was as unreal as if, theorizing in old times about the raising of dough by yeast, one party should have invoked a 'brownie,' while another insisted on a 'fairy' as the true cause of the phenomenon."[3]

It is astonishing to see how many philosophical disputes collapse into insignificance the moment you subject them to this simple test of tracing a concrete consequence. There can *be* no difference anywhere that doesn't *make* a difference elsewhere—no difference in abstract truth that doesn't express itself in a difference in concrete fact and in conduct consequent upon that fact, imposed on somebody, somehow, somewhere and somewhen. The whole function of philosophy ought to be to find out what definite difference it will make to you and me, at definite instants of our life, if this world-formula or that world-formula be the true one.

[3] 'Theorie und Praxis,' *Zeitsch. des Oesterreichischen Ingenieur u. Architecten-Vereines*, 1905, Nr. 4 u. 6. I find a still more radical pragmatism than Ostwald's in an address by Professor W. S. Franklin: "I think that the sickliest notion of physics, even if a student gets it, is that it is 'the science of masses, molecules and the ether.' And I think that the healthiest notion, even if a student does not wholly get it, is that physics is the science of the ways of taking hold of bodies and pushing them!" (*Science*, January 2, 1903.)

There is absolutely nothing new in the pragmatic method. Socrates was an adept at it. Aristotle used it methodically. Locke, Berkeley and Hume made momentous contributions to truth by its means. Shadworth Hodgson keeps insisting that realities are only what they are 'known as.' But these forerunners of pragmatism used it in fragments. They were a prelude only. Only in our time has it generalized itself, become conscious of a universal mission, pretended to a conquering destiny. I believe in that destiny, and I hope I may end by inspiring you with my belief.

Pragmatism represents a perfectly familiar attitude in philosophy, the empiricist attitude, but it represents it, as it seems to me, both in a more radical, and in a less objectionable form than it has ever yet assumed. A pragmatist turns his back resolutely and once for all upon a lot of inveterate habits dear to professional philosophers. He turns away from abstraction and insufficiency, from verbal solutions, from bad *a priori* reasons, from fixed principles, closed systems, and pretended absolutes and origins. He turns towards concreteness and adequacy, towards facts, towards action, towards power. That means the empiricist temper regnant, and the rationalist temper sincerely given up. It means the open air and possibilities of nature, as against dogma, artificiality and the pretence of finality in truth.

At the same time it does not stand for any special results. It is a method only. But the general triumph of that method would mean an enormous change in what I called in my last lecture the 'temperament' of philosophy. Teachers of the ultra-rationalistic type would be frozen out, much as the courtier type is frozen out in republics, as the ultramontane type of priest is frozen out in protestant lands. Science and metaphysics would come much nearer together, would in fact work absolutely hand in hand.

Metaphysics has usually followed a very primitive kind of quest. You know how men have always hankered after unlawful magic, and you know what a great part, in magic, *words* have always played. If you have his name, or the formula of incantation that binds him, you can control the spirit, genie, afrite, or whatever the power may be. Solomon knew the names of all the spirits, and knowing their names, he held them subject to his will. So the universe has always appeared to the natural mind as a kind of enigma, of which the key must be sought in the shape of some illuminating word or some power-bringing word or name. That word names the universe's *Principle,* and to possess it is, after a fashion, to possess the universe itself. 'God,' 'Matter,' 'Reason,' 'the Absolute,' 'Energy,' are so many solving names. You can rest when you have them. You are at the end of your metaphysical quest.

But if you follow the pragmatic method, you can not look on any such word as closing your quest. You must bring out of each word its

practical cash-value, set it at work within the stream of your experience. It appears less as a solution, then, than as a program for more work.

Theories thus become *instruments,* not answers to enigmas, in which we can rest. We don't lie back upon them, we move forward by their aid. Pragmatism unstiffens all our theories, limbers them up and sets each one at work. Being nothing essentially new, it harmonizes with many ancient philosophic tendencies. It agrees with nominalism, for instance, in always appealing to particulars; with utilitarianism in emphasizing practical aspects; with positivism in its disdain for verbal solutions, useless questions, and metaphysical abstractions.

All these, you see, are *anti-intellectualist* tendencies. Against rationalism as a pretension and a method, pragmatism is fully armed and militant. But, at the outset, at least, it stands for no particular results. It has no dogmas, and no doctrines save its method. As the young Italian pragmatist Papini has well said, it lies in the midst of our theories, like a corridor in a hotel. Innumerable chambers open out of it. In one you may find a man writing an atheistic volume; in the next, some one on his knees praying for faith and strength; in a third a chemist investigating a body's properties. In a fourth a system of idealistic metaphysics is being excogitated; in a fifth the impossibility of metaphysics is being shown. But they all own the corridor, and all must pass through it if they want a practicable way of getting into or out of their respective rooms.

No particular results then, so far, but only an attitude of orientation, is what the pragmatic method means. The attitude of looking away from first things, principles, 'categories,' supposed necessities; and of looking towards last things, fruits, consequences, facts.

So much for the pragmatic method! Meanwhile the word pragmatism has come to be used in a still wider sense, as meaning also a certain *theory of truth.* I ask for your redoubled attention here. If much remains obscure, I hope to make it clearer in the later lectures.

One of the most successfully cultivated branches of philosophy in our time is what is called inductive logic, the study of the conditions under which our sciences have evolved. Writers on this subject have begun to show a singular unanimity as to what the laws of nature and elements of fact mean, when formulated by mathematicians, physicists and chemists. When the first mathematical, logical and natural uniformities, the first *laws,* were discovered, men were so carried away by the clearness, beauty and simplification that resulted, that they believed themselves to have deciphered authentically the eternal thoughts of the Almighty. *His* mind also reverberated in syllogisms. He also thought in conic sections, squares and roots, and ratios, and geometrized like Euclid. He made Kepler's laws for the

planets to follow; he made velocity increase proportionally to the time in falling bodies; he made the laws of the sines for light to obey when refracted; he established the classes, orders, families and genera of plants and animals, and fixed the distances between them. He thought the archetypes of all things, and devised their variations; and when we re-discover any one of these his wondrous institutions, we seize his mind in its very literal intention.

But as the sciences have developed farther, the notion has gained ground that most, perhaps all, of our laws are only approximations. The laws themselves, moreover, have grown so numerous that there is no counting them; and so many rival formulations are proposed in all the branches of science that investigators have become accustomed to the notion that no theory is absolutely a transcript of reality, but that any one of them may from some point of view be useful. Their great use is to summarize old facts and to lead to new ones. They are only a man-made language, a conceptual shorthand, as Pearson calls them, in which we write our reports of nature; and languages, as is well known, tolerate much choice of expression and many dialects.

Thus human arbitrariness has driven divine necessity from scientific logic. If I mention the names of Sigwart, Mach, Ostwald, Pearson, Milhaud, Poincaré, Duhem, Heymans, those of you who are students will easily identify the tendency I speak of, and will think of additional names.

Riding now on the front of this wave of scientific logic Messrs. Schiller and Dewey appear with their pragmatistic account of what truth everywhere signifies. Everywhere, these men say, 'truth' in our ideas and beliefs means the same thing that it means in science. It means, they suggest, nothing but this, that ideas become true just in so far as they help us to get into satisfactory relation with the other parts of our experience, to synthesize and summarize facts and other ideas, and get about among them by conceptual short-cuts instead of following the interminable labyrinth of particular phenomena as they succeed one another. Any idea upon which we can ride, so to speak; any idea that will carry us prosperously from any one part of our experience to any other part; linking things satisfactorily, working securely, simplifying, saving labor, is true for just so much, true in so far forth, true *instrumentally*. This is the 'instrumental' view of truth taught so successfully at Chicago, the view that truth means the power of our ideas to 'work,' promulgated so brilliantly at Oxford.

Messrs. Dewey, Schiller and their allies, in reaching this general notion of all truth, have only followed the example of geologists, biologists and philologists. In the establishment of these other sciences, the successful stroke was always to take some simple process actually observable in operation—as denudation by weather, say, or

variation from parental type, or change of dialect by incorporation of new words and pronunciations—and then to generalize it, to make it apply to all times, and produce great results by summating its effects through ages.

The process which Schiller and Dewey particularly singled out for generalization is the familiar one by which any individual *settles into new opinions.* The process here is always the same. The individual has a stock of old opinions already, but he meets a new experience that puts them to a strain. Somebody contradicts them; or in a reflective moment he discovers that they contradict each other; or he hears of facts with which they are incompatible; or desires arise in him which they cease to satisfy. The result is an inward trouble to which his mind till then had been a stranger, and from which he seeks to escape by modifying his previous mass of opinions. He saves as much of it as he can, for in this matter of belief we are all extreme conservatives. So he tries to change first this opinion, and then that (for they resist change very variously), until at last some new idea comes up which he can graft upon the ancient stock with a minimum of disturbance of the latter, some idea that mediates between the stock and the new experience and runs them into one another most felicitously and expediently.

This new idea is then adopted as the true one. It preserves the older stock of truths with a minimum of modification, stretching them just enough to make them admit the novelty and conceiving that in ways as familiar as the case leaves possible. An *outrée* explanation, violating all our preconceptions, would never pass for a true account of a novelty. We should scratch round industriously till we found something less excentric. The most violent revolutions in an individual's beliefs leave most of his old order standing. Time and space, cause and effect, nature and history, and one's own biography remain untouched. New truth is always a go-between, a smoother-over of transitions. It marries old opinion to new fact so as ever to show a minimum of jolt, a maximum of continuity. We hold a theory true just in proportion to its success in solving this 'problem of maxima and minima.' But success in solving this problem is eminently a matter of approximation. We say this theory solves it on the whole more satisfactorily than that theory; but that means more satisfactorily to ourselves, and individuals will emphasize their points of satisfaction differently. To a certain degree, therefore, everything here is plastic.

The point I now urge you to observe particularly is the part played by the older truths. Failure to take account of it is the source of many of the unjust criticisms leveled against pragmatism. The influence of elder truths is absolutely controlling. Loyalty to them is the first principle—in most cases it is the only principle. The most usual way of handling phenomena so novel that they would make for a serious

rearrangement of our preconceptions is to ignore them altogether, or to abuse those who bear witness for them.

You doubtless wish examples of this process of truth's growth, and the only trouble is their superabundance. The simplest case of new truth is of course the mere numerical addition of new kinds of fact, or of new facts of old kinds, to our experience—an addition that involves no alteration in the old beliefs. Day follows day, and its contents are simply added. The new contents themselves are not true, they simply *come* and *are*. Truth is *what we say about* them, and when we say that they have come, truth is satisfied by the plain additive formula.

But often the day's contents oblige a rearrangement. If I should now utter piercing shrieks and act like a maniac on this platform, it would make many of you revise your ideas as to the probable worth of my philosophy. 'Radium' came the other day as part of the day's content, and seemed for a moment to contradict our ideas of the whole order of nature, that order having come to be identified with what is called the conservation of energy. The mere sight of radium paying heat away indefinitely out of its own pocket, seemed to violate that conservation. What to think? If the radiations from it were nothing but an escape of unsuspected 'potential' energy, preexistent inside the atoms, the principle of conservation would be saved. The discovery of 'helium' as the radiation's outcome, opened a way to this belief. So Ramsay's view is generally held to be true, because, although it extends our old ideas of energy, it causes a minimum of alteration in their nature.

I need not multiply instances. A new opinion counts as 'true' just in proportion as it gratifies the individual's desire to assimilate the novel in his experience to his beliefs-in-stock. It must both lean on old truth and grasp new fact; and its success (as I said a moment ago), in doing this, is a matter for the individual's appreciation. When old truth grows, then, by new truth's addition, it is for subjective reasons. We are in the process and obey the reasons. That new idea is truest which performs most felicitously its function of satisfying our double urgency. It *makes* itself true, gets itself classed as true, by the way it works; grafting itself then upon the ancient body of truth, which grows, thus, much as a tree grows by the activity of a new layer of cambium.

Now Dewey and Schiller proceed to generalize this observation and to apply it to the most ancient parts of truth. They also once were plastic. They also were called true for human reasons. They also mediated between still earlier truths and what in those days were novel observations. Purely objective truth, truth in whose establishment the function of giving human satisfaction in marrying one part of experience with another played no part whatever, is nowhere to be

found. The reason why we call things true is the reason why they *are* true, for 'to be true' *means* only to perform this marriage function.

The trail of the human serpent is thus over everything. Truth independent; truth that we *find* merely; truth no longer malleable to human need; truth incorrigible, in a word; such truth exists indeed superabundantly—or is supposed to exist by rationalistic-minded thinkers. But that means only the dead heart of the living tree, it means only that truth also has its paleontology, and may grow stiff with years of veteran service and petrified in men's regard by sheer antiquity. How plastic even the oldest truths still really are has been vividly shown in our day by the transformation of logical and mathematical ideas, a transformation which seems even to be invading physics. The ancient formulas are reinterpreted as special expressions of much wider principles, principles that our ancestors never got a glimpse of in their present formulation.

Mr. Schiller gives to all this view of truth the name of 'Humanism,' but, for this doctrine too, the name of pragmatism seems to be in the ascendant, not only in America but on the European continent, so I must treat it also in these lectures.[4]

Such then would be the scope of pragmatism—a method and a genetic theory of what is meant by truth. And these two things must be our future topics.

What I have said of the theory of truth will, I am sure, have appeared obscure and unsatisfactory to most of you by reason of its brevity. You may not follow me wholly in this preliminary lecture; and if you do, you may not wholly agree with me. But you will, I know, already regard me at least as serious, and treat my effort with respectful consideration.

You will probably be surprised to learn, then, that Messrs. Schiller's and Dewey's theories have suffered a hailstorm of contempt and ridicule. All rationalism has risen against them. In influential quarters Mr. Schiller, in particular, has been treated like an impudent schoolboy who deserved a spanking. I shouldn't mention this, but for the fact that it throws so much side-light upon that rationalistic temper to which I have opposed the temper of pragmatism. Pragmatism is uncomfortable away from facts. Rationalism is comfortable only in the presence of abstractions. This pragmatist talk about truths in the plural, about their utility and satisfactoriness, about the success with which they 'work,' etc., suggests to the typical intellectualist mind a sort of coarse lame makeshift article of truth. Such truths are not real

[4] Even while I correct the proof I receive Mr. Schiller's new volume, 'Studies in Humanism,' N. Y. The Macmillan Company, pp. 492. The title shows that Mr. Schiller still clings to his term.

truth. Such tests are merely subjective. As against this, objective truth must be something non-utilitarian, haughty, refined, remote, august, exalted. It must be an absolute correspondence of our thoughts with an equally absolute reality. It must be what we *ought* to think, unconditionally. The ways in which we *do* think are so much irrelevance and matter for psychology. Down with psychology, up with logic, in all this question!

See the exquisite contrast of the types of mind! The pragmatist clings to facts and concreteness, observes truth at its work in particular cases, and generalizes. Truth, for him, becomes a class-name for definite working values in experience. For the rationalist it remains a pure abstraction, to the bare name of which we must defer. When the pragmatist undertakes to show in detail just *why* we must defer, the rationalist is unable to recognize the concretes from which his own abstraction is taken. He accuses us of *denying* truth, whereas we have only sought to trace exactly why people follow it and always ought to follow it. Your typical ultra-abstractionist fairly shudders at concreteness. Other things equal, he positively prefers the pale and spectral. If the two universes were offered, he would always choose the skinny outline rather than the rich thicket of reality. It is so much purer, clearer, nobler.

I hope that as these lectures go on, the concreteness and closeness to facts of the pragmatism which they advocate may be what approves itself to you as its most satisfactory peculiarity. It only follows here the example of the sister sciences, interpreting the unobserved by the observed. It brings old and new harmoniously together. It converts the absolutely empty notion of a bare static relation of 'correspondence' (whatever that may mean) between our minds and reality, into that of a rich and active commerce, that any one may follow in detail and understand, between particular thoughts of ours, and the great universe of other experiences in which they play their parts and have their uses.

But enough of this at present? The justification of what I say must be postponed. I wish now to add a word in further explanation of the claim I made at our last meeting, that pragmatism may be a happy harmonizer of empiricist ways of thinking, with the more religious demands of human beings.

Men who are strongly of the fact-loving temperament, you may remember me to have said, are liable to be kept at a distance by the unsympathetic tone of the philosophy which present-day idealism offers them. It is too intellectualistic for them. Old-fashioned dualistic theism was bad enough, with its notion of God as an exalted monarch, made up of a lot of unintelligible or preposterous 'attributes'; but, so long as it held strongly by the argument from design,

it kept some touch with concrete realities. Since, however, Darwinism has once for all displaced design from the minds of the 'scientific,' theism has lost that foothold; and some kind of an immanent or pantheistic deity working *in* things rather than above them is, if any, the kind desired by our contemporary imagination. Aspirants to a philosophic religion turn, as a rule, more hopefully nowadays towards idealistic pantheism than towards the older dualistic theism, in spite of the fact that the latter still counts able defenders.

But, as I said in my first lecture, the brand of pantheism offered is hard for them to assimilate if they are lovers of facts, or empirically minded. It is the absolutistic brand, spurning the dust and reared upon pure logic. It keeps no connection whatever with concreteness. Affirming the Absolute Mind, which is its substitute for God, to be the rational presupposition of all particulars of fact, whatever they may be, it remains supremely indifferent to what the particular facts in our world actually are. Be they what they may, the Absolute will father them. Like the sick lion in Esop's fable, all footprints lead into his den, but *nulla vestigia retrorsum*. You can not redescend into the world of particulars by the Absolute's aid, or deduce any necessary consequences of detail, important for your life, from your idea of his nature. He gives you, indeed, the assurance that all is well with *Him*, and for his eternal way of thinking; but thereupon he leaves you to be finitely saved by your own temporal devices.

Far be it from me to deny the majesty of this conception, or its capacity to yield religious comfort to a most respectable class of minds. But from the human point of view, no one can pretend that it doesn't suffer from the faults of remoteness and abstractness. It is eminently a product of what I have ventured to call the rationalistic temper. It disdains empiricism's needs. It substitutes a pallid outline for the real world's richness. It is dapper; it is 'noble' in the bad sense, in the sense in which to be noble is to be inapt for humble service. In this real world of sweat and dirt, it seems to me that when a view of things is 'noble,' that ought to count as a presumption against its truth, and as a philosophic disqualification. The prince of darkness may be a gentleman, as we are told he is, but whatever the God of earth and Heaven is, He can surely be no gentleman. His menial services are needed in the dust of our human trials, even more than his dignity is needed in the empyrean.

Now pragmatism, devoted though she be to facts, has no such materialistic bias as ordinary empiricism labors under. Moreover, she has no objection whatever to the realizing of abstractions, so long as you get about with their aid among particulars, and they actually carry you somewhere. Interested in no conclusions but those which our minds and our experiences work out together, she has no *a priori* prejudices against theology. If theological ideas prove to have a

working value for concrete life, they will be true, for pragmatism, in the sense of being *good for so much.* For how much *more* they are good, will depend on their relations to the other truths acknowledged.

What I said just now about the Absolute of transcendental idealism is a case in point. First, I called it majestic and said it yielded religious comfort to a class of minds, and then I accused it of remoteness and sterility. But so far as it affords such comfort, it surely is not sterile; it has that amount of cash value; it performs a concrete function. As a good pragmatist, I ought myself to call the Absolute true 'in so far forth,' then; and I unhesitatingly now do so.

But what does 'true in so far forth,' 'true for so much,' mean in this case? To answer, we need only apply the pragmatic method. What do believers in the Absolute mean by saying that their belief affords them comfort? They mean that since in the Absolute finite evil is 'overruled' already, we may, therefore, whenever we wish, treat the temporal as if it were potentially the eternal, be sure that we can trust its outcome, and without sin dismiss our fear and drop the worry of our finite responsibility. In short, they mean that we have a right ever and anon to take a moral holiday, to let the world wag in its own way, feeling that its issues are in better hands than ours and are none of our immediate business.

The universe is a system of which the individual members may relax their anxieties occasionally, in which the don't-care mood is also right for men, and moral holidays in order—that, if I mistake not, is part, at least, of what the Absolute is 'known as,' that is the great difference in our particular experiences which his being true makes for us, that is his cash value when he is pragmatically interpreted. Farther than that the ordinary lay-reader in philosophy who thinks favorably of absolute idealism does not venture to sharpen his conceptions. He can use the Absolute for so much, and so much is very precious. He is pained at hearing you speak incredulously of the Absolute, therefore, and disregards your criticisms because they deal with aspects of the conception that he does not follow.

If the Absolute means this, and means no more than this, who can possibly deny the truth of it? To deny it would be to insist that men should never relax, and that holidays are never in order.

I am well aware how odd it must seem to some of you to hear me say that an idea is 'true' so long as to believe it is profitable to our lives. That it is *good,* for as much as it profits, you will gladly admit. If what we do by its aid is good, the idea itself is good in so far forth, for we are the better for possessing it. But is it not a strange misuse of the word 'truth' to call ideas also 'true' for this reason?

To answer this difficulty fully is impossible at this stage of my account. You touch here upon the very central point of Messrs.

Schiller's, Dewey's and my own doctrine of truth, which I can not discuss with detail until my sixth lecture.[5] Let me now say only this, that truth is *one species of good,* and not, as is usually supposed, a category distinct from good, and coordinate with it. The true is the name of whatever proves itself to be *good in the way of belief,* and good, moreover, for definite practical reasons. Surely you must admit this, that if there were no value for life in true ideas, or if the knowledge of them were positively disadvantageous and false ideas the only useful ones, then the current notion that truth is divine and precious, and its pursuit a duty, would never have grown up or become a dogma. In a world like that, the duty would be to *shun* truth, rather. But in this world, just as certain foods are not only agreeable to our taste, but good for our teeth, our stomach and our tissues; so certain ideas are not only agreeable to think about, or agreeable as supporting other ideas that we are fond of, but they are also helpful in life's practical struggles. If there be any life that it is really better we should lead, and if there be any idea which, if believed in, would help us to lead that life, then it would be really *better for us* to believe in that idea—unless, indeed, belief in it incidentally clashed with other greater vital benefits.

'What it would be best that we should believe'! This sounds very like a definition of truth. It comes very near to saying 'what we *ought* to believe,' and in *that* definition of truth none of you would find any oddity. Ought we ever to believe what it is not *better for us* to believe? And can we then keep the notion of what is better for us, and what is true for us, permanently apart?

Pragmatism says no, and I fully agree with her. Probably you also agree, so far as the abstract statement goes, but with a suspicion that if we practically did believe everything that made for good in our own personal lives, we should be found indulging all kinds of foolish fancies about this world's affairs, and all kinds of sentimental superstitions about a world hereafter. Evidently something does happen, when you pass from the abstract to the concrete, that complicates the situation.

I said just now that what it is best that we should believe is true *unless the belief incidentally clashes with some other vital benefit.* Now in real life what vital benefits is any particular belief of ours most liable to clash with? What indeed except the vital benefits yielded by other beliefs when these prove incompatible with the first ones? In other words, the greatest enemy of any one of our truths may be *the rest of our truths.* Truths have once for all this desperate instinct of self-preservation and of desire to extinguish whatever contradicts them. Grant that the Absolute may be true in giving me a moral holiday. Nevertheless, as I conceive it (and I proceed to speak, now not as an

[5] That sixth lecture will soon appear in the *Journal of Philosophy, Psychology and Scientific Methods.*

abstract pragmatist, but merely in my own private person), it clashes with other truths of mine whose benefits I hate to give up on its account. It is associated with a kind of logic of which I am the enemy; it entangles me in metaphysical paradoxes that are inacceptable, etc., etc. But I have enough trouble in life already without the added trouble of carrying these intellectual inconsistencies, so I give up the Absolute. Personally, I just *take* my moral holidays; or else as a professional philosopher, I try to justify them by some other principle.

If I could restrict my notion of the Absolute to its bare holiday-giving value, it wouldn't clash with my other truths. But we can not easily thus restrict our hypotheses. They carry supernumerary features, and these it is that clash so. My disbelief in the Absolute means disbelief in those other supernumerary features.

You see by this what I meant when I called pragmatism a mediator and reconciler and said that she 'unstiffens' our theories.[6] She has in fact no prejudices whatever, no obstructive dogmas, no rigid canons of what shall count as proof. She is completely genial. She will entertain any hypothesis, she will consider any evidence. It follows that in the religious field she is at a great advantage both over positivistic empiricism, with its anti-theological bias, and over religious rationalism with its exclusive interest in the remote, the noble and the abstract in the way of conception.

In short, she widens the field of search for God. Rationalism sticks to logic and the empyrean. Empiricism sticks to the external senses. Pragmatism for her part is willing to take anything, to follow either logic or the senses, and to count the humblest and most personal experiences. She will count mystical experiences if they have practical consequences. She will take a God who lives in the very dirt of private fact—if that should seem a likely place to find him.

Her only test of probable truth is what works best in the way of leading us, what fits every part of life best and combines with the collectivity of experience, nothing being omitted. If theological ideas should do this, if the notion of God, in particular, should prove to do it, how could pragmatism possibly deny God's existence? She could see no meaning in treating as 'not true' a notion that was pragmatically so successful. You see how democratic she is. Her manners are as various and flexible, her resources as rich and endless, and her conclusions as obedient and malleable as those of mother nature.

[6] I get this word from Papini (Leonardo, Aprile, 1905).

CIVOLOGY—A SUGGESTION

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SO far civilization—Johnson 'abominated' the word and suggested 'civility' instead—has been considered philosophically, described historically, viewed esthetically and computed statistically. I say 'so far,' and I may add 'so good,' for by these disciplines the phenomena in question have been arrayed under their vicarious aspects with illuminating, impressive, interesting and significant results. Hence we have systems, narratives, tales and tables, all of which are well enough in their respective ways. As a whole, however—if one can consider them collectively—these systems, narratives, tales and tables lack continuity. Coordination is required, so, it seems to me, civilization should be subjected to scientific research. Ours is the age of science, we affirm; certainly each century has contributed its quota. To the credit of the nineteenth belongs biology, which has succeeded in coordinating the phenomena of life; it is the task of the twentieth, I take it, to coordinate the phenomena of civilization and afford us the science of, *Civology,* shall I say?

But why, you ask, is a new science necessary? Civilization is the work of man and anthropology, the science of man, is already established. Beavers build dams, but there's not one science of beavers and another of their dams, why, then, one science of man and another of his works? If men established civilizations by instinct, as beavers build dams, and the same sorts of civilizations from generation to generation, with only such changes as are effected through selection, there would be no necessity of a separate science, but such is not the case. Civilization is not instinctive and conservative, it is purposive and progressive. So there is something in the distinction Spencer sought to establish between organic and super-organic phenomena. Man himself is an organic phenomenon, his works, however, are super-organic—to be sure, they proceed, as Spencer said, by insensible steps out of the organic, even as organic phenomena proceed by insensible steps out of the inorganic, still for this very reason they are *super*-organic. Since such is the case, manifestly man and his works can not be included within one science; there must be two sciences, one of man, and another of his works. It is of no avail—in fact it only mixes matters the more—to divide anthropology into two parts: physical anthropology, which purports to deal with man himself, and cultural anthropology.

which sets out to consider his works. Inasmuch as man is an organic phenomenon, anthropology, the science of man—like botany, the science of plants, and zoology, the science of animals—is properly speaking a branch of biology, the general science of all organic phenomena. Call this physical anthropology if you prefer—though the adjective seems to me superfluous—but pause and consider before you speak of cultural anthropology. The adjective in this case is incongruous; cultural includes man's works, which are confessedly super-organic. Now there may be no principles capable of coordinating these super-organic phenomena—if so there can be no such thing as a science of civilization—but simply because these principles are still unknown, or unknowable, if you like, is no reason why other known principles should be accepted to serve their stead. You can not coordinate organic phenomena under inorganic categories, why should you expect to coordinate super-organic phenomena under organic categories? But this is precisely what is proposed by the incongruous combination: *cultural anthropology*—the science itself is organic, its subject-matter is super-organic.

Congruity requires that the new science shall be super-organic to correspond with its subject-matter. But there is such a science, you say, sociology, which claims to be *the* science of super-organic phenomena. If 'social' and 'super-organic' were synonymous, as Spencer supposed, the claim would be justified, but they're not, and no amount of argument or assumption can make them so. To go no further for the moment, it is evident enough man's works are individual and familial as well as social; then too, from another point of view, some of man's works are economic, others esthetic, and so on, all of which are included within the broader concept 'civilization,' but not necessarily within the narrower concept 'society.' Thus though sociology is, logically at least, *a* science of super-organic phenomena, it is certainly not *the* science of super-organic phenomena, since it does not, and can not be made to coordinate the subject-matter in question. All organic phenomena are coordinated under the general science of biology, perhaps some day all super-organic phenomena will be coordinated under the general science of civology. If so, sociology will constitute one of the subsidiary sciences of civology, even as morphology constitutes one of the subsidiary sciences of biology. Till then the so-called science should be classed among the above-mentioned 'systems.' Even as such—if I may add a word by way of criticism—it is not a striking success—to quote from a recent writer: "In regard to the fundamental principles of sociology, the confusion is hopeless. The student will search in vain in the systematic treatises on sociology for any definite body of established doctrine which he can accept as the ground principles of the science. He finds only an unmanageable mass of conflicting theories and opinions. Each treatise contains an exposition

of what the author is pleased to label the 'Principles of Sociology.' But the 'Principles' are not the same in any two treatises; and by no process of analysis and synthesis can they be brought into harmony. They are fundamentally contradictory. It is impossible, I believe, to discover a single alleged ground-principle of sociology that has commanded general assent."[1] If so, well may Gabriel Tarde advise his fellow sociologists: "Instead of discoursing upon the merits of this infant sociology—which men have had the art to baptize before its birth—let us succeed, if possible, in bringing it forth."

Setting aside cultural anthropology as inadequate and sociology as insufficient, I revert to the necessity of a new science. As to its name, it is premature, perhaps, to baptize this infant also before its birth, but I may at least be allowed to suggest *Civology*. I do so for consistency's sake; life is organic, civilization is super-organic, the organic science of life is called biology, the super-organic science of civilization should be called civology. I assume, you see, that civilization and super-organic are synonymous, and rightly, I think; certainly all civil phenomena are super-organic, the only question is: are all super-organic phenomena civil? They are essentially so, I should say, and, in any event, civilization is such a flexible term it may very well, far better, in fact, than any other, be extended so as to include all the phenomena in question. But enough of the name, now for the substance of the new science. Its subject-matter is super-organic; so much is established. The next step is to formulate fundamental principles capable of coordinating super-organic phenomena—an exceedingly long step. Indeed it is, so long, I fear I shall be obliged to jump at conclusions. Fortunately the path is well paved to this point, and beyond the general direction of advance is defined. So far science exhibits an orderly processus of phenomena, with the result that organic phenomena have been shown to proceed by insensible steps out of the inorganic. I assume simply that such consistency continues to the end, with the result that super-organic phenomena proceed by insensible steps out of the organic. If so, civology stands in the same relation to biology that biology stands to physics and chemistry. The fundamental principles of biology are subsequent to and consistent with the fundamental principles of its antecedent sciences, physics and chemistry; accordingly, the fundamental principles of civology should be subsequent to and consistent with the fundamental principles of its antecedent science, biology. Before taking the step—or making the leap, if you like—it will be best, then, to go back a bit, and, passing the line of organic evolution in review, run over the fundamental principles of biology.

Organic evolution is characterized by countless variations, according to which the manifold forms of life can be classified under more

[1] F. Spencer Baldwin, 'Sociology,' POPULAR SCIENCE MONTHLY, LV., p. 817.

or less definite categories—kingdoms, sub-kingdoms, classes, orders, families, genera, species and varieties, with many intermediate divisions—and arranged in an ascending series culminating, as we view it, in man. The extrinsic cause, or perhaps I should say the condition, of these variations is *environment*. The intrinsic cause is the physiological principle of *variability*, or *mutability*, by which biologists mean the susceptibility to modification inherent in organic life, 'that plasticity or modifiability of any organism in virtue of which an animal or a plant may change in form, structure, function, size, color, or other character, lose some character or acquire another, and thus deviate from its parent form.' This tendency of all organisms to become unlike their parents is, as I say, in first instance an intrinsic quality, and, like other natural attributes, transmissible from generation to generation. But though originally instrinsic, variability is only called into play by extrinsic conditions. As a result, organic variations are the outcome of an interaction between intrinsic and extrinsic factors, variability and environment. Looking along the line of organic evolution, the general tendency appears to be toward the preservation of the more useful and the extinction of the less useful or useless characters. This is due, in first instance, to adaptation, and then to the fact that selection in one form or another has been operative all along the line, eliminating the unfit or ill-adapted from the struggle for existence and allowing only the fittest or best adapted to survive. *Selection* acts accordingly as the regulative factor of organic evolution—so in last analysis variations become "the accomplishment of that which variability permits, environment requires, and selection directs." To be noted also is the fact that variability, or the tendency to vary under environmental conditions, is counteracted to a considerable extent by *heredity*, or the tendency to breed true, the former being the progressive, the latter the conservative, principle of organic evolution.

Man himself is an animal, the final product, apparently, of organic evolution. Classified biologically he belongs to the sub-kingdom: *Vertebrata*, class: *Mammalia*, order: *Primates*, sub-order: *Anthropoidea*, family: *Hominidae*, which family constitutes one genus and a single species. In the course of its evolution this single species has, however, become further differentiated into at least four sub-species, which constitute the great races of man—and these in turn into a great number of ethnic varieties. Arranged in an ascending series, we rank the Negro, or Black race, lowest; next the American, or Red race; then the Mongolic, or Yellow race, and finally the Caucasic, or White race. Within this last we take the Anglo-Saxons to represent the highest ethnic type—though this is more or less arbitrary, depending upon the point of view. But whatever the order of arrangement, there can be no doubt of this: these several races and numerous varieties of man-

kind represent so many organic variations of the human species, effected through the interaction of variability and environment, and established by adaptation and selection. Now each of these races and every variety of the human species has contributed something to the sum total of civilization. So it seems, in man's case, the line of organic evolution is succeeded and supplemented by a line of super-organic development. And as the line of organic evolution is characterized by countless variations culminating in the several races and numerous varieties of man, even so is the line of super-organic development characterized by successive states of civilization, established by the several races and numerous varieties of man. These states of civilization likewise can be classified according to their complexity and arranged in an ascending series, culminating, if you like, in the existing civilization of the Anglo-Saxons—though this again is a matter of opinion, or prejudice perhaps. But whatever the order of their arrangement, of this I am quite convinced: these states of civilization connote in last analysis so many *systems of utilization.* My concept of the subject may seem somewhat restricted, but I assure you it will expand as we proceed, meanwhile I ask you only to accept the connotation provisionally, as a possible point of departure.

This at least is obvious: in order to live and move and have their being—to say nothing of meliorating their material condition—human beings are obliged to utilize the resources at their disposal. The manners in which and the means and methods whereby they do so are determined by the circumstances—physical, social and historical—within which they strive. *Circumstance* constitutes, accordingly, the extrinsic cause or condition of utilization. The intrinsic cause in this case is the psychological principle of *utility,* which is the quality of satisfying wants—an elusive and very variable quality, to be sure, none the less appreciable for all that. All men seek to satisfy their wants, therefore all men may be said to strive after utility. The quality in question supplies, as it were, the stimulus, the incentive, or better perhaps, the motive that makes for utilization. So I should say utility constitutes the progressive principle of super-organic development, even as variability constitutes the progressive principle of organic evolution. To acquire such utility and so satisfy their wants, men, as I have said, must utilize the resources at their disposal, in the manner and by the means and methods most in accordance with their circumstances. So it appears super-organic systems of utilization are, like organic variations, the outcome of an interaction between intrinsic and extrinsic factors, utility and circumstance in this case. Looking along the line of super-organic development, the general tendency appears to be toward the augmentation of utility accompanied by increasing complexity in the process of utilization. This is due to the expansion of

human wants, the satisfaction of one usually causing another to emerge in the mind, and so on indefinitely. Circumstances conscribe and restrict such expansion always and everywhere; so, not being able to satisfy all their wants at once, men are compelled to choose between the satisfaction of one and the satisfaction of another. Such choice is effected through evaluation, which comes in last analysis to this: in every set of circumstances each man asks himself, 'to the satisfaction of which of my many wants do I attach the most immediate importance? which, in a word, is most worth while?' and having decided, proceeds to utilize his resources accordingly. The same is true in a more general way of peoples and races; as a result of a long series of evaluations, groups as well as individuals establish their standards in accordance with their physical, social and historical circumstances. So I should say: *evaluation* constitutes the regulative factor of super-organic development. If so, utilization becomes in last analysis the accomplishment of that which utility suggests, circumstances allow and evaluation controls. A word in conclusion: because of the expansion of human wants, utility constitutes the progressive principle of super-organic development, but utility is counteracted to a considerable extent by imitation, the disposition to accept traditionally established standards and utilize in accordance with custom and convention instead of circumstance—*imitation* constitutes accordingly the conservative principle of super-organic development.

Before stepping over from the formulated organic into the unformulated super-organic, in order to indicate the direction and measure the distance I said: the fundamental principles of civology should be subsequent to and consistent with the fundamental principles of its antecedent science, biology. Having taken the step—or made the leap, if you like—let us look about us and see where we have landed. In the first place, are the super-organic principles suggested consistent with the organic principles already established? They seem to me so —I appeal to comparison. Biology has succeeded in coordinating the phenomena of life; the task I set civology was to coordinate the phenomena of civilization. The phenomena of life are organic, the phenomena of civilization are super-organic. The former, that is the phenomena of life, present themselves to science as variations; the latter, that is the phenomena of civilization, should, I say, present themselves to science as systems of utilization. Organic variations are conceived of by biology as the accomplishment of that which variability permits, environment requires, and selection directs; so, it seems to me, super-organic systems of utilization should be conceived of by civology as the accomplishment of that which utility suggests, circumstance allows and evaluation controls. The parallelism between the two processes is apparent: Both proceed from intrinsic principles which

are progressive in character—the organic process from the principle of variability, the super-organic process from the principle of utility. In each case the progressive action of these intrinsic principles is conscribed and restricted by extrinsic conditions—variability by environmental conditions, utility by circumstantial conditions. In each case also the interaction of intrinsic principles and extrinsic conditions is directed and controlled by factors which are neither intrinsic nor extrinsic, but rather intermediate in character—the interaction of variability and environment by selection, the interaction of utility and circumstance by evaluation. Finally, both processes are arrested and established to some extent by the influence of other intrinsic principles that are conservative in character, the organic process by heredity, the super-organic process by imitation. But enough of this, a parallelism pushed too far comes dangerously near an analogy. In another paper I shall endeavor to show in what sense the suggested principles of super-organic development are subsequent to the known principles of organic evolution.

THE RECLAMATION OF THE NORTH PLATTE VALLEY

By W. S. COULTER,
ASSISTANT ENGINEER, U. S. R. S.

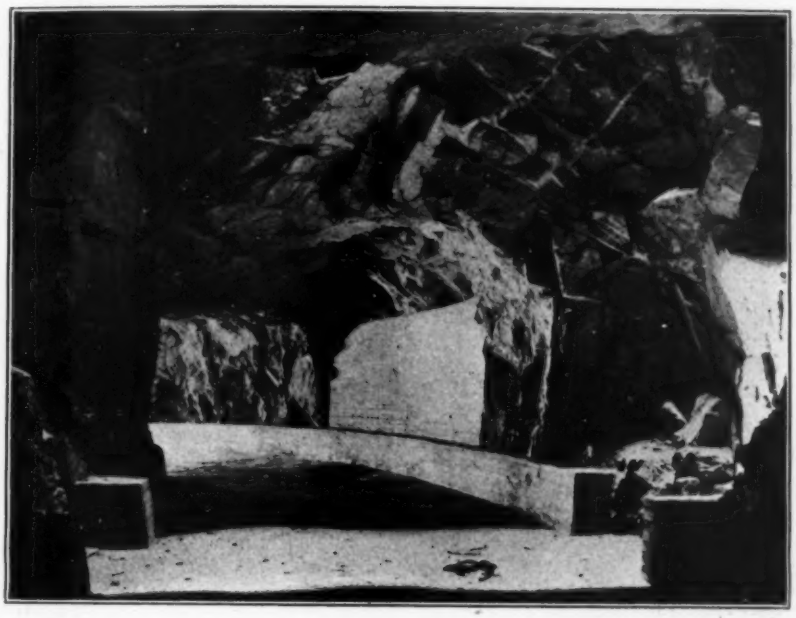
THE North Platte River rises in the semi-arid region of the North Park Mountains in Colorado and flows into Wyoming, its course through the latter state describing a rough quadrant of about one hundred and fifty miles radius, having for its center the southeast corner of the state. Eighty miles from the state line it turns to the southeast and so continues to its junction with the South Platte in central Nebraska. The route through the last two states lies almost wholly

PATHFINDER CANYON ON THE NORTH PLATTE RIVER. LOCATION OF DAM SITE.

within the arid region and drains, in Wyoming, a mountainous country where the snow lingers long into the early summer. During the winter and spring the snowfall upon the peaks is considerable, and when the white mantle begins to dissolve under the increasing heat of the summer sun, the rivers are gorged with the flood waters. The North Platte, which trickles along the center of a broad gravel bed throughout the summer, a pigmy sporting the habiliments of a giant, assumes monstrous proportions at this season, swelling from a few hundred

second-feet in August to as much as twenty thousand in May, and the uncouth pile bridges that, stretched meaninglessly for hundreds of feet over a stream confined within the limits of a single bent, find their shore abutments awash with the mighty swirl.

Were there no mountains to gather and release the frozen supply, the North Platte might always remain a comparatively small stream of equalized flow, as the precipitation is slight on these brown, arid plains, and the soil absorbs moisture with avidity. Because of this lack of moisture, the soil, though rich in plant constituents, is not susceptible to cultivation, excepting where its position relative to the river margin is such that irrigation may be practised. Many thousands of acres of land, favorably situated, lie along the banks of the North



INTERIOR OF PATHFINDER DIVERSION TUNNEL.

Platte, especially in the extreme easterly part of Wyoming and in Nebraska, and the settlers have utilized the river waters individually and through cooperative associations for the past two decades.

The strength of a heavy chain, when measured by the resistance of its weakest link, may be very small. The total annual flow of the North Platte is large, but the maximum discharge occurs in the spring and early summer at, or slightly before, the beginning of the irrigating season. Throughout the period of irrigation the flow diminishes until, in the sweltering days of August, the torrent of May is reduced to the dimensions of a respectable creek. The amount of land that may be successfully irrigated by waters diverted directly from the river must

FIFTY-FOOT CUT ON THE INTERSTATE CANAL.

be measured by this minimum flow during the irrigating season, and unless some method be found whereby the floods of spring may be utilized during the summer months, only a limited area of the fertile lands along the river can be reclaimed.

The solution of the problem obviously lies in the construction of a storage reservoir having a capacity sufficient to retain the flood waters of spring, releasing them during the summer months as needed. The construction of such a storage reservoir and dam, with the auxiliary diversion dams, headworks and canals, and the adjustment of rights of way, water rights and other perplexing legal matters, is a task requiring large sums of money and efficient organization—sums so vast and organization so perfect that no combination of settlers in a new, sparsely settled country could hope to achieve it. Private capital may be advanced by outside parties if a private monopoly of the water-supply be granted, but in such a case the water users must be always resisting the encroachments that follow the private ownership of natural monopolies. The capital may be advanced by outside parties and the works constructed under their supervision, not for the purpose of obtaining a private monopoly, but to turn the whole over to an organization of the water users when they shall have refunded the cost of installation plus a reasonable return at current rates of interest. There is but one party powerful enough and philanthropic enough to do this, and, if the arid regions are to be equitably reclaimed without the creation of powerful private monopolies, it is to the national government

that we must look for assistance. The disinterested position and financial sufficiency of the government and the power it possesses to coordinate those portions of projects lying in different states render it peculiarly competent to undertake this work.

As a result of thorough preliminary investigations, a reservoir site for the storage of the waters of the North Platte was located near the mouth of the Sweetwater River in central Wyoming. The site is a natural basin, the enclosure having but one outlet, through which the river escapes by a granite gorge extending for a quarter of a mile through the hills. This canyon is approximately two hundred feet deep and one hundred feet wide, and presents an ideal site for a dam by which to convert the basin above into an immense storage reservoir, while the surrounding hills of fine-grained granite contain the materials for construction. The one unfavorable feature is the location of the dam site with reference to the railroads, the nearest point being forty-five miles distant. The thousands of barrels of cement and the contractor's heavy plant must be transported over this long stretch of earth road, materially increasing the cost of construction. Yet the natural fitness of the site is such that the cost of the dam and appurtenances relative to the body of water impounded is but one dollar per acre-foot stored.

The dam to be constructed at this point will be of the arch type, ninety-four feet thick at the base, two hundred and ten feet high and about two hundred and thirty feet long at the crest. The preliminary

VIEW NEAR BRIDGEPORT, NEBRASKA, SHOWING TYPICAL AREA OF LAND IT IS PROPOSED TO IRRIGATE.

estimate of stone masonry is fifty-three thousand cubic yards and of concrete one thousand cubic yards, together calling for forty thousand barrels of cement. The contract for the dam, exclusive of a cut-off and dike, was awarded September 1, 1905, for $482,000, the government to furnish the cement at the nearest railroad point. During the summer a tunnel was constructed through the canyon walls, the upper portal located above and the lower portal below the dam site, for the purpose of diverting the waters of the river during the construction of the dam and to be used later for the passage of stored water.

The annual run-off from the Pathfinder watershed is about 1,500,000 acre-feet, and the capacity of the proposed reservoir is 1,025,000 acre-feet, being sufficient to retain about two thirds of the entire discharge of the North Platte at this point for one year. A conservative estimate of the area it is possible to irrigate under favorable circumstances, with the amount of water to be stored in the Pathfinder Reservoir, lies between 300,000 and 400,000 acres. During the irrigating season it is proposed to allow the surplus water stored in the reservoir to escape into the river bed as needed, augmenting the normal flow, to be intercepted by diversion dams and turned into the headworks of the canals that are to conduct it to the lands it is intended to irrigate.

The irrigable lands lying below the reservoir have been surveyed, and wherever it seemed that any considerable area could be reclaimed for a reasonable expenditure, a preliminary location of canals and study of the necessary structures involved were made and the probable cost estimated. Some of the schemes were rejected because of excessive cost and others are in abeyance, but the Interstate Canal has been pronounced practicable by a consulting board of engineers and is now in process of construction. This canal heads at a point about eight miles above old Fort Laramie in Wyoming and follows the northerly side of the valley for one hundred and fifty miles to a point near Bridgeport, Nebraska. The land underlying this canal in the extreme eastern part of Wyoming and in Nebraska is of excellent quality, requiring but the application of sufficient water to yield bountiful returns. No alkali demands the construction of expensive underdrains on these lands, and, with the lands south of the river and those lying higher up the valley in Wyoming, there is an area sufficient to exhaust even the resources of the huge Pathfinder Reservoir. A conservative estimate of the probable area underlying the Interstate Canal, and to receive its service, is something more than 100,000 acres. The canal is designed to carry about 1,400 second-feet of water at the headworks. The first forty-five miles was divided into ten contracts, which were awarded during the months of June and July, 1905, and construction has been in progress throughout the summer, with the outlook bright for water in time for the irrigating season of 1906. In November the second fifty miles was awarded. There are no tunnels on the Interstate Canal and

no expensive construction, the alignment following the outlying gravel knolls along the bluff that borders the valley, occasionally intercepting these or encountering short stretches of Brule clay. In the quality and extent of irrigable lands and their favorable juxtaposition to economical canal alignments, the North Platte project is favored in its distribution system as well as in storage facilities.

The average rainfall over the irrigated area will probably not exceed thirteen inches per annum. The mean temperature is 45°, the maximum 98°, and the minimum — 20° Fahrenheit, and the length of the growing season is sufficient to mature most of the crops raised in this latitude, including corn. The principal crop at present grown is alfalfa, with some corn, oats, wheat, sugar beets and potatoes. The principal supply market is Omaha, but Denver, Kansas City and St. Joseph are contributory. The greater part of the produce will be marketed in the west, unless demand and supply shall be sufficiently disturbed to unsettle their present balance.

Taking eighty acres as a unit and assuming the total area to be irrigated under the North Platte project as 300,000 acres, there will be 3,750 farms. Assuming that the average family consists of five persons, we have 18,750 persons occupying these lands.

Adding to these the merchants, blacksmiths, carpenters, doctors, clergymen and others, with their families, for whom this population will provide patronage, the total becomes approximately thirty thousand persons, exclusive of a probable additional population employed in canning factories. This community will be based upon good homes on the land, free from tenantry and collectively participating in the natural opportunity upon which each irrigator depends. The population at present inhabiting these lands is small, numbering not more than a couple of thousand persons.

This work of the Reclamation Service with its promise of partial relief from the urban congestion that threatens the nation is carried forward by moneys received from the sale of public lands. These moneys are restored to the government by the water users and all possibility of initial tenantry is prevented by the stipulation that tracts exceeding a certain size, between forty and one hundred and sixty acres, must be subdivided and sold to persons who will use them to obtain a livelihood before water will be placed on the land.

It has been well said that the safeguard of a nation is a large population of working farmers, owning the land they use, and as a means for the partial accomplishment of this desirable condition, the work of the Reclamation Service deserves commendation.

SHORTER ARTICLES.

A VOCABULARY TEST

PROFESSOR KIRKPATRICK'S article in a recent number of the POPULAR SCIENCE MONTHLY leads me to present the results of an investigation on practically the same lines, extending over several years when I was engaged in teaching college students to read German. I used a dictionary test, a little different in detail, but practically the same as Professor Kirkpatrick's, to find the number of German words which could be defined by students when they entered the second year's work in the subject in college. Some of them had had one year's college instruction, and others were admitted on examination.

I found that the vocabulary of those who could pass such an examination was never less than 2,000 words, and went from that up to 5,000. The mark received on the examination was in close relation to the extent of the vocabulary. Those who had more than 5,000 words were generally fit to go into a higher course.

The test was repeated at the end of the year. The result then was from 5,000 to 12,000 words. The marks on the final examination of the second year's course were also in close relation to the extent of the vocabulary. I tried this with classes for several years, getting sufficiently uniform results to prove conclusively to my mind that these were the normal figures.

I was then interested to extend the investigation to English, and had several classes make the same experiment for their own language, but with the very important feature that I used an unabridged dictionary, containing over 100,000 words, instead of one containing only 28,000. I found that most of the college sophomores reported from 50,000 to 60,000 words. Of course, if they had had only 28,000 to select from, it would not be surprising if they had reported only 20,000; and I think that Professor Kirkpatrick made a mistake in using so small a book. I found that students who had not studied Greek regularly reported from 10,000 to 15,000 words less than those who had.

I also experimented with a number of people who had never been to college, but, with an ordinary common school education, were regular readers of books and periodicals. These reported generally from 25,000 to 35,000 words, though some of them went higher, even as high as the lower figures of the college students.

I then took a few cases of the working vocabulary in foreign languages of those really proficient in them, chiefly among modern language teachers. The results are probably fairly typified by my own case, which could, no doubt, be matched by almost any one who has made a life study of different languages. I found that my English vocabulary was about 65,000 words; German (counting all compounds given in the dictionary), 58,000; Danish (largely the same roots as German), 52,000; French, 30,000; Italian, 22,000; Latin, 18,000; Spanish, 16,000; Greek, 13,000, and Old Norse, 11,000.

I should guess that these figures, which are for languages belonging to only two general families, could be reduced to 20,000 or 30,000 actual roots, or perhaps even less; but to verify such a guess would require an investigation with a system of slips, for which I probably shall never have time. I leave the interpretation of these facts to the reader, who can be assured that they are facts.

E. H. BABBITT.

THE PROGRESS OF SCIENCE

A NATIONAL DEPARTMENT OF PUBLIC HEALTH

THE physicians of the country and the American Medical Association have long advocated the establishment of a department of public health as part of the national government, and they now have the cooperation of an influential committee of one hundred, which had its origin at the Ithaca meeting of the American Association for the Advancement of Science. Professor Norton, of Yale University, there read a paper on the economic advisability of a national department of health in which he pointed out the waste due to preventable death and disease. Apart from the incalculable misery, the saving in money that could be effected in this country was placed at from two to four billion dollars a year. Professor Fisher, of Yale University, who was chairman of the section of economic and social science of the association, is chairman of the committee of one hundred, which includes many of those most active in all good works, such as Presidents Eliot, Hadley, Angell and Gilman, Drs. Welch, Bryant and Biggs, the surgeon generals of the army and navy, Messrs. Felix Adler and Lyman Abbott, and others of equal influence. It may not be easy for such a committee to agree on a definite plan, but their recommendations should carry great weight with the president and the congress.

The first question appears to be as to whether a national department of health with a cabinet officer should be advocated or whether only a bureau should be recommended for the present. It is a curious fact that our cabinet is smaller and less democratic than that of any other great nation. We alone have no ministry of education. Certainly the fusion of the war and navy departments with one secretary only and the establishment of three new departments and cabinet ministers —one of science, one of education and one of health—would more nearly represent what should be the proper functions of government than our present system. But this is a question for the future. A less radical reorganization, and one within the range of possibility, should sensible people unite to advocate it, would be the transference of pensions from the Department of the Interior to the army and navy, where they belong, leaving the Department of the Interior free to become essentially a department of science, education and health, whose representative in the cabinet should be a man such as President Eliot or Dr. Welch. Apart from pensions and the land office (which latter might be transferred to the Department of Agriculture or of Commerce and Labor), the Department of the Interior now consists of the Bureau of Education and of Indian Affairs, the Patent Office and the Geological Survey. If bureaus of science, of public health and of fine arts were added, the Department of the Interior would become a 'Cultusministerium.' It appears likely that the most that can be accomplished by the committee of one hundred and the American Medical Association at present would be the establishment of a Bureau of Health coordinate with the Bureau of Education under the Department of the Interior. The function of these two bureaus for the present would be mainly that of coordination and the collection and diffusion of information, but they would be free to develop as rapidly as the general sentiment of the country permitted.

It is not evident that all the work of the government for science or for public health should be concentrated in one department or bureau. Under existing conditions it is probably better that they should be found in each department. Thus the Agricultural Department is substantially a Department of Agricultural Science, and the Navy Department should become a Department of Naval Science, the Treasury Department a Department of Economic Science, etc. It is a distinct advantage that work on behalf of health should now be done under at least six of the nine departments of the federal government. What we need is an increase in amount, range and scientific productivity of the work done under each department, and a new bureau which can coordinate this work and cooperate in its extension.

THE RESEARCH DEPARTMENTS OF THE CARNEGIE INSTITUTION

APPENDED to the report of the president of the Carnegie Institution for 1906 are accounts of the scientific work carried forward under the auspices of the institution during the year. In addition to some forty minor grants, amounting in all to nearly $100,000, there were eleven departments, for the support of which over $450,000 was appropriated.

The largest appropriation last year was for the department of solar physics under the direction of Professor George E. Hale. Further progress has been made in equipping the observatory on Mt. Wilson, and a road has been built to the summit. Research has been carried forward in various direc-

MT. WILSON, FROM MT. HAMILTON, THE SEAT OF THE SOLAR OBSERVATORY OF THE CARNEGIE INSTITUTION.

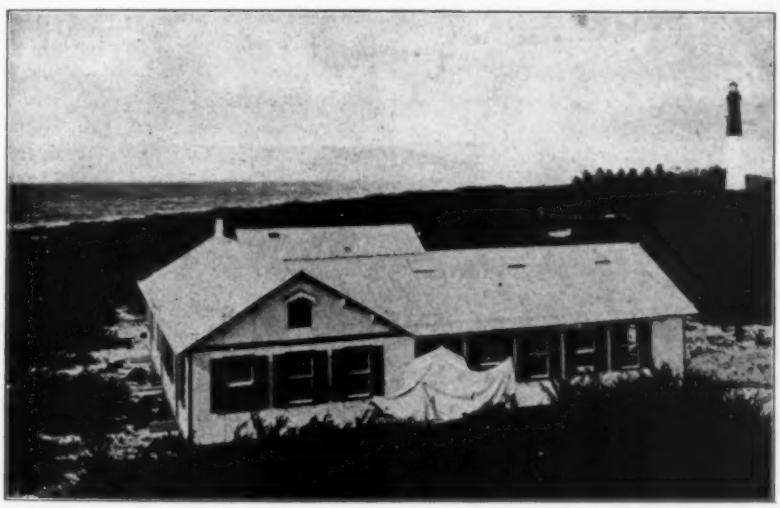
tions, including photography of the sun and of the spectra of sun-spots. Mr. John D. Hooker, of Los Angeles, has made a gift of $45,000 for a mirror of one-hundred-inch aperture for a great reflecting telescope. The largest new project planned was also for astronomy and consists of an appropriation of $200,000 extending over a decade for a catalogue giving the precise positions of the brighter stars. This involves the establishment of a meridian observatory in the southern hemisphere. The execution of the work has been entrusted to Professor Lewis Boss, director of the Dudley Observatory at Albany.

Next to astronomy, geophysics is most liberally supported by the institution. A special laboratory for geophysical research is being erected in Washington at a cost of $150,000. Dr. A. L. Day, who will have charge of the department, succeeded last year in producing quartz glass, which is of value owing to its high melting point and low rate of expansion under temperature changes. Work in terrestrial magnetism under Dr. L. A. Bauer, who has resigned his position in the U. S. Coast and Geodetic Survey, is supported by an appropriation of $54,000. The yacht *Galilee* made last year two voyages in the Pacific, traversing some 26,000 miles.

A new department, established last year, was that of botanical research, under the direction of Dr. D. T. MacDougal, whose headquarters are the Desert Laboratory at Tucson, Ariz. The flora of the arid regions has been studied, including the vegetation of the Salton Basin, while Dr. MacDougal has continued his experiments at the New York Botanical Garden on discontinuous variation in plants. One of the larger projects is also the work in horticulture of Mr. Luther Burbank.

Two departments are devoted to biology. Work in experimental evolution is conducted under the direction of Professor Charles B. Davenport at Cold Spring Harbor, where land has been secured and a laboratory erected. The other is the department of marine biology conducted under Dr. A. G. Mayer at the Dry Tortugas, Florida. A temporary laboratory has been built there.

Work in nutrition has been carried on by Professor F. G. Benedict, Professor R. S. Chittenden and Professor F. B. Osborne. This is regarded as one



VIEW OF THE MAIN LABORATORY AT THE TORTUGAS STATION FOR MARINE BIOLOGY OF THE CARNEGIE INSTITUTION.

VIEW ACROSS COLD SPRING VALLEY LOOKING SOUTHEASTWARD, SHOWING PART OF THE GROUNDS OF THE STATION FOR EXPERIMENTAL EVOLUTION OF THE CARNEGIE INSTITUTION. Main building at the extreme right, potting house and propagating house in front, and vivarium, under construction, in front of and to left of latter. To the left (north) of the main building is seen part of the east experimental garden. Near the extreme left is the brooder house, from which radiate eight poultry runs, seen in the middle foreground.

of the major projects, and it is planned to continue it on a more extensive scale, funds having been appropriated for the erection of a laboratory, which will be placed under the direction of Professor Benedict. It is stated that the laboratory will be built where pathological cases can be secured for investigation, and it is now reported that it will be placed in Boston.

The two remaining departments are economics and sociology and historical research. The former, under the direction of President Carroll D. Wright, of Clark College, is preparing an economic history of the country with the assistance of more than a hundred collaborators. As head of the department of historical research, Professor J. F. Jameson has succeeded Professor A. C. McLaughlin. The department aims to be a clearing-house for the historical profession, and is engaged in various miscellaneous activities, thus differing somewhat from the other departments.

It will be of great importance for science to learn whether research work can be conducted more economically and efficiently in institutions of this character than when combined with educational work, as at our universities, or with economic work, as under the government. More than half the income of the institution is appropriated for work in astronomy and geophysics, in which subjects the president is especially competent, but it may be doubted whether it is an advantage for institutions in California, Arizona, Florida, New York, Massachusetts and South America to be conducted from Washington. It would probably be better if the laboratories were built and endowed, and their future development entrusted to local control.

THE SAGE FOUNDATION

ANOTHER great foundation on the lines of those established by Mr. Carnegie and Mr. Rockefeller is now announced. Mrs. Russell Sage has offered to give ten million dollars to a board to be incorporated by the New York legislature for a foundation the object

of which shall be "the improvement of social and living conditions in the United States. The means to that end will include research, publication, education, the establishment and maintenance of charitable and beneficial activities, agencies and institutions, and the aid of any such activities, agencies and institutions already established." The original trustees are: Robert W. De Forest, Cleveland H. Dodge, Daniel C. Gilman, John M. Glenn, Miss Helen Gould, Mrs. William B. Rice, Miss Louisa L. Schuyler and Mrs. Sage.

This foundation represents a movement that is likely to become dominant in the twentieth century. The future of the race depends largely upon whether what Dr. Galton has named 'eugenics' can be made a science and applied for our welfare. We trust that the income will not be used mainly to establish or assist charitable institutions, but rather for the purposes first stated above—research, publication and education. The difficulties are undoubtedly very great, and the first step must probably be to train those competent to deal with the complex conditions. But increased interest in the scientific aspects of the problems is full of promise for the future.

THE PROBLEMS OF ASTRONOMY

At the eighth annual meeting of the Astronomical and Astrophysical Society of America, held December 27 to 29, 1906, at Columbia University, New York, Professor E. C. Pickering, director of the Harvard College Observatory, on taking the chair, discussed three lines of work which he believed the society should pursue. According to the report of the editor, Professor Harold Jacoby, these are: First, by cooperation to carry out some great routine investigation too extensive to be undertaken by a single observatory. The best example of this was the accurate determination of the positions of the northern stars by European and American observatories, under the direction of the Astronomische Gesellschaft. Second, to bring together socially astronomers from all parts of the country, especially the older and younger men. The latter may think the work of the older men out of date, but they may find the experience of the older men and their personal acquaintance with the eminent men of still earlier date of great assistance. The older men have much to learn regarding new methods, and the extensive appliances at their command may often be employed to much greater advantage if they keep themselves personally in touch with the most recent developments of astronomical research. Third, the presentation of papers. While hitherto this has been the principal function of this and other societies it is not necessarily the most valuable. General discussions are more interesting and instructive than long technical papers. It may, therefore, be wise to follow the example of some of the engineering societies, and print abstracts of papers for distribution some days before the meeting. A brief statement is made by the author of each paper, and the greater portion of the time is devoted to discussion. The ideal conditions for meetings of the society would seem to be—a large hotel where all would eat and sleep under the same roof, and where the meetings could be held in the same building.

On the afternoon of December 28 a general discussion took place regarding neglected fields of work in astronomy, in which a large number of members took part, and the views expressed were varied and interesting. The president, in opening the discussion, cited a number of examples of fields of work, which seemed to him important but neglected. For example, in the astronomy of position the formation of a standard catalogue of stars uniformly distributed, having similar spectra, and of nearly the same magnitude. Many trouble-

some sources of error, like those due to magnitude and color, would thus be eliminated. The variation in latitude should be studied at a series of southern stations like those now in operation in the northern hemisphere. The systematic search for double stars of the ninth magnitude and brighter, undertaken at the Lick Observatory, should be extended to the south pole. Photometric measures of faint stars, of comparison stars for faint variables, of the components of clusters, and of nebulæ, are much needed. It is not known whether the spectra of nine tenths of the nebulæ are gaseous or continuous. A wide field is opened in the study of the spectra of bright variables when faint, and of faint variables when bright, of the distribution of faint spectra and of the components of clusters.

SCIENTIFIC ITEMS

WE record with regret the deaths of the following men of science: Professor Dimitri Ivanovitch Mendeléef, the eminent chemist, director of the Russian Bureau of Weights and Measures; M. Henri Moissan, professor of general chemistry at the Sorbonne and director of the Institute of Applied Chemistry; Sir Michael Foster, professor of physiology in the University of Cambridge, secretary of the Royal Society from 1881 to 1903, president of the British Association in 1899, and member of parliament for London University; Professor Wilhelm von Bezold, director of the Royal Prussian Meteorological Institute; Professor Nicholas Menschutkin, professor of chemistry at St. Petersburg; Mr. William Wells Newell, of Cambridge, Mass., known for his researches in folk-lore, especially in connection with the Arthurian tales, secretary of the American Folk-lore Society; Professor Wilbur Samuel Jackman, who held the chair of the teaching of natural science in the School of Education of the University of Chicago; Dr. David Irons, professor of philosophy at Bryn Mawr College; Charles B. Simpson, entomologist of the Department of Agriculture of the Transvaal, and formerly of the U. S. Department of Agriculture, and Dr. John Krom Rees, since 1881 professor of geodesy and astronomy and director of the Observatory of Columbia University.

BY special act of Congress Dr. James Carroll has been made a major in the medical department of the army, in recognition of his important work in yellow fever.—Colonel W. C. Gorgas, chief sanitary officer of the Isthmian Canal Commission, has been appointed by President Roosevelt a member of the commission.

M. DANIEL OSIRIS has left by his will a sum of $5,000,000 to the Pasteur Institute of Paris.—Rensselaer Polytechnic Institute has received a gift of $1,000,000 from Mrs. Russell Sage. The money will be used for the School of Mechanical and Electrical Engineering. Mrs. Sage has also given $1,000,000 to the Emma Willard School of Troy.